Travel Model Two Development: Verification of Model Mechanics

Technical Paper

Metropolitan Transportation Commission with Parsons Brinckerhoff, Inc.

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1 Introduction

MTC is rebuilding the representation of supply in our travel model. When complete, the new representations of supply will be joined with a new representation of demand to form the *Travel Model Two* modeling system.

This technical paper represents the final, aside from on-going cleaning up, step in the supply development effort. The representations of supply, specifically the representations of space, roadways, transit service, sidewalks, and bicycle ways have been built, and the application software has been refactored. The model system has not been calibrated or validated. The purpose of this paper is to document that the model software is working as intended, i.e. the mechanics are being carried out as expected. While the model system has not been calibrated or validated, the results are still expected to be in the same ballpark as the calibrated system. As such, results are examined in this light: do they suggest the model system is working as expected.

Each section below discusses an individual model component, with a brief introduction to its functionality followed by one or more analyses of its results. These analyses are not intended as calibration or validation of the model's correctness with regards to reality, but rather a verification that the model components are working as intended. At the end of the paper, a summary of model runtimes is presented.

Note that this paper expects a deep familiarity with the nascent *Travel Model Two* system. For detailed documentation, please see the MTC/ABAG Analytical Modeling Wiki.

2 Networks

2.1 Non-Motorized Network

The procedure to create the non-motorized networks (walk and bike) extracts the links from the network which have CNTYPE equal to TANA, PED/BIKE, MAZ, TAZ, or TAP and which are not freeways, or which have the BIKEPEDOK flag set to true (1). For the pedestrian network, any link that is one-way has an opposite direction link generated.

The following table presents a cross-tabulation of CNTYPE and facility type for the links in the pedestrian network. All of the non-TANA links are correctly identified as having no facility type, and the zone connector counts are roughly in-line with the counts of each zone type (|MAZ| > |TAP| > |TAZ|). Additionally, as expected, few freeway or freeway-related links are included in the pedestrian network (the small number of included TANA freeway links are bridges which allow pedestrians).

Table 1 : Cross-Tabulation of CNTYPE by Facility Type for Pedestrian Network

	CNTYPE					
Facility Types	MAZ	PED	TANA	TAP	TAZ	All
Freeway-Freeway Connector	-	-	-	-	-	-
Freeway	-	-	40	-	-	40
Expressway	-	-	33,219	-	-	33,219
Collector	-	-	627,017	-	-	627,017
Freeway Ramp	-	-	2	-	-	2
Major Arterial	252,926	-	-	43,508	63,068	359,502
Special Facility	-	-	227,741	-	-	227,741
Pedestrian	-	221,905	-	-	-	221,905
All	252,926	221,905	888,019	43,508	63,068	1,469,426

The following tables present the total length of the links in the pedestrian network segmented by facility type and CNTYPE. All links in the pedestrian network has a facility type assigned to it. Zone connectors are coded as major arterials – this was assumed for ease of scripting. There is no direct implication on the skim values (travel times/distances) because of this assumption. We can see that the majority of the links (86%) are either collectors or arterials. About 40% are MAZ/TAZ/TAP connectors. While pedestrian-only links comprise just over 2% of links, they do add over 2400 miles to the entire pedestrian network.

Table 2 : Total Pedestrian Network Length by Facility Type

Facility Types	Length (mi)	% of Total
Freeway-Freeway Connector	-	0%
Freeway	10	0%
Expressway	2,253	2%
Collector	51,965	48%
Freeway Ramp	0	0%
Major Arterial	41,121	38%
Special Facility	11,037	10%
Pedestrian	2,424	2%
All	108,810	100%

Table 3 : Total Pedestrian Network Length by CNTYPE

CNTYPE	Length (mi)	% of Total
MAZ	18,606	17%
PED	2,424	2%
TANA	65,265	60%
TAP	271	0%
TAZ	22,244	20%
All	108,810	100%

The following table presents a cross-tabulation of CNTYPE and facility type for the links in the bicycle network. As with the pedestrian network, all of the non-TANA links are correctly identified as having no facility type, and their counts are sensible in comparison to the zone counts. A few thousand bike-only (CNTYPE = BIKE) links are included in the network. Additionally, as expected, a few freeway or freeway-related links are included in the bike network (the small number of included TANA links are bridges which allow bicycles).

Table 4 : Cross-Tabulation of CNTYPE by Facility Type for Bicycle Network

	CNTYPE						
Facility Types	**BIKE**	**MAZ**	**PED**	**TANA**	**TAP**	**TAZ**	**All**
Freeway-Freeway Connector	-	-	-	-	-	-	-
Freeway	-	-	-	20	-	-	20
Expressway	-	-	-	21,485	-	-	21,485
Collector	-	-	-	600,801	-	-	600,801
Freeway Ramp	-	-	-	1	-	-	1
Major Arterial	-	252,926	-	-	43,508	63,068	359,502
Special Facility	-	-	-	162,798	-	-	162,798
Pedestrian	6,678	-	34	-	-	-	6,712
All	6,678	252,926	34	785,105	43,508	63,068	1,151,319

The following tables present the total length of the links in the bicycle network segmented by facility type and CNTYPE. As with the pedestrian network, the zone connectors are classified as major arterials. Looking at the distribution of bike network length by CNTYPE, we note that bike-specific links add over 2500 miles to the bicycle network.

Table 5 : Total Bicycle Network Length by Facility Type

Facility Types	Length (mi)	% of Total
Freeway-Freeway Connector	-	0%
Freeway	5	0%
Expressway	1,635	2%
Collector	50,777	49%
Freeway Ramp	0	0%
Major Arterial	41,121	39%
Special Facility	8,456	8%
Pedestrian	2,562	2%
All	104,556	100%

Table 6 : Total Bicycle Network Length by CNTYPE

CNTYPE	Length (mi)	% of Total
BIKE	2,558	2%
MAZ	18,606	18%
PED	3	0%
TANA	60,873	58%
TAP	271	0%
TAZ	22,244	21%
All	104,556	100%

2.2 Highway Network

The process to create highway networks consists of procedures which set tolls for the various bridge and toll crossings, determines the area type for a given link (used in the CAPCLASS lookup field), and builds a highway network for each time period with a calculated free-flow travel time.

The following tables present cross-tabulations of area type, facility class, free-flow speed, and CNTYPE for the network. Note that all tabulations are made on the midday (MD) network. The links with the higher free-flow speeds are freeways and expressways, with "lesser" facility types (arterials, collectors, *etc.*) having lower free-flow speeds in distributions that would be expected.

The distribution of the facility types is as expected, with the specialty links (connectors, ramps, special facility) present in significantly less numbers compared to the more common links. The distribution amongst these more common links is also sensible.

The zone connector counts are roughly in-line with the counts of each zone type (|MAZ| > |TAZ|). Please note that highway network need not be connected to TAPs.

Table 7: Cross-Tabulation of Facility Type by Area Type for the Highway Network (table holds the number of links of each facility type and CNTYPE combinations)

	Area Type							
Facility Types	**Unclassified**	**Regional Core**	**CBD**	**Urban Business**	**Urban**	**Suburban**	**Rural**	**All**
Freeway-Freeway Connector	-	6	33	52	134	347	36	608
Freeway	-	117	392	883	2,694	8,731	2,797	15,614
Expressway	-	-	138	907	3,759	9,572	7,208	21,584
Collector	-	1,236	4,809	16,592	71,478	365,443	138,701	598,259
Freeway Ramp	-	18	118	341	1,276	3,261	668	5,682
Major Arterial	252,926	852	2,194	5,607	15,990	41,039	6,334	324,942
Special Facility	-	1,386	3,776	8,632	34,097	97,537	17,370	162,798
All	252,926	3,615	11,460	33,014	129,428	525,930	173,114	1,129,487

Table 8 : Cross-Tabulation of Facility Type by Free Flow Speed for the Highway Network (table holds the number of links of each facility type and CNTYPE combinations)

	Free Flow Speed						
Facility Types	**0-25**	**25-35**	**35-45**	**45-55**	**55-65**	**65+**	**All**
Freeway-Freeway Connector	-	-	23	438	144	3	608
Freeway	-	1	693	1,363	7,149	6,408	15,614
Expressway	76	463	21,045	-	-	-	21,584
Collector	598,259	-	-	-	-	-	598,259
Freeway Ramp	4,283	958	16	284	122	19	5,682
Major Arterial	-	324,942	-	-	-	-	324,942
Special Facility	3,723	159,075	-	-	-	-	162,798
All	606,341	485,439	21,777	2,085	7,415	6,430	1,129,487

Table 9 : Cross-Tabulation of Facility Type by CNTYPE for the Highway Network (table holds the number of links of each facility type and CNTYPE combinations) [1]

	CNTYPE					
Facility Types	**EXT**	**MAZ**	**TANA**	**TAZ**	**USE**	**All**
Freeway-Freeway Connector	-	-	608	-	-	608
Freeway	-	-	15,614	-	-	15,614
Expressway	-	-	21,584	-	-	21,584
Collector	-	-	598,259	-	-	598,259
Freeway Ramp	-	-	5,682	-	-	5,682
Major Arterial	44	252,926	-	63,068	8,904	324,942
Special Facility	-	-	162,798	-	-	162,798
All	44	252,926	804,545	63,068	8,904	1,129,487

[1] Please note that the CNTYPE code "USE" is used to denote HOV dummy connector links – these are links that are coded to connect HOV lanes to the general purpose lanes.

The next table presents the average free-flow speed for the motorized network, segmented by facility type. As with the free-flow speed/facility type cross-tabulation, the average speeds are sensible and change as expected.

Table 10 : Average Free Flow Speed by Facility Type for the Highway Network

Facility Types	Average Free Flow Speed
Freeway-Freeway Connector	47.37
Freeway	57.39
Expressway	34.73
Collector	17.59
Freeway Ramp	21.70
Major Arterial	25.00
Special Facility	27.16
All	22.02

The following tables present the total length of the links in the motorized network, segmented by facility type and area type. About 88% of the total road way length is Collector or Major arterials and 70% of the total roadway length is in the suburban and rural portions of the nine county Bay Area.

Table 11 : Total Highway Network Length by Facility Type

Facility Types	Length (mi)	% of Total
Freeway-Freeway Connector	66	0%
Freeway	1,843	2%
Expressway	1,640	2%
Collector	50,392	49%
Freeway Ramp	569	1%
Major Arterial	40,860	39%
Special Facility	8,456	8%
All	103,826	100%

Table 12 : Total Highway Network Length by Area Type

Facility Types	Length (mi)	% of Total
Unclassified	18,606	18%
Regional Core	212	0%
CBD	683	1%
Urban Business	2,315	2%
Urban	9,271	9%
Suburban	40,291	39%
Rural	32,448	31%
All	103,826	100%

2.3 Transit Network

The transit network is built from a base node and link network layer with transit lines read on top of it using Cube's PUBLIC TRANSPORT program. During this process the network nodes are renumbered so the TAP nodes become zones for skimming and assignment and the transit line files are also rebuilt using the modified node numbers. Different transit networks are created for each time period, with different transit lines enabled for each whether or not they are running in the period. The transit lines are read in during the transit skimming and assignment procedures, and the summaries discussed here refer to the transit networks built during transit skimming. Please refer to the transit skimming procedure for details regarding the path builder settings.

The table below presents some metrics reported during the transit network building process. Most of the measures seem reasonable, with the AM and PM (peak) periods showing more transit lines. SET1 skims have only local services enabled; while SET2 and SET3 have all services enabled – hence we see Cube PT picking up more route bundles (sets of potential routes between zones) in these sets compared to local only set. Also, there are no "walk only" routes. Presence of walk transfer legs indicates that the link generation procedure for walk transfers is being applied correctly.

Table 13 : Transit Network Statistics by Time Period [Route Bundles in millions]

Time Period	EA			AM			MD			PM			EV		
Transit Lines	482			1,192			843			1,082			803		
Direct Non-Transit Legs	4,736			9,398			7,436			8,675			7,448		
Access Legs	11,408			17,262			16,116			16,995			15,170		
Egress Legs	11,408			17,262			16,116			16,995			15,170		
Transfer Legs	54,870			100,398			92,210			98,976			85,542		
Walk only routes	0			0			0			0			0		
Non-Transit Legs	147,576			152,238			150,276			151,515			150,288		
Transit Legs	510,187			853,743			664,395			747,579			760,488		
Transit Mode	**SET1**	**SET2**	**SET3**	**SET1**	**SET2**	**SET3**	**SET1**	**SET2**	**SET3**	**SET1**	**SET2**	**SET3**	**SET1**	**SET2**	**SET3**
Line Zone Legs	47,190	47,585	47,585	90,834	91,399	91,399	70,037	70,320	70,320	82,494	82,894	82,894	71,801	72,330	72,330
Line to Line Legs	40,060	41,793	41,793	114,571	119,537	119,537	63,310	64,287	64,287	90,900	94,504	94,504	77,425	79,777	79,777
Route Bundles	4.57	9.37	9.80	7.99	16.18	17.53	6.87	14.09	15.11	7.78	15.75	17.03	7.45	13.63	14.72

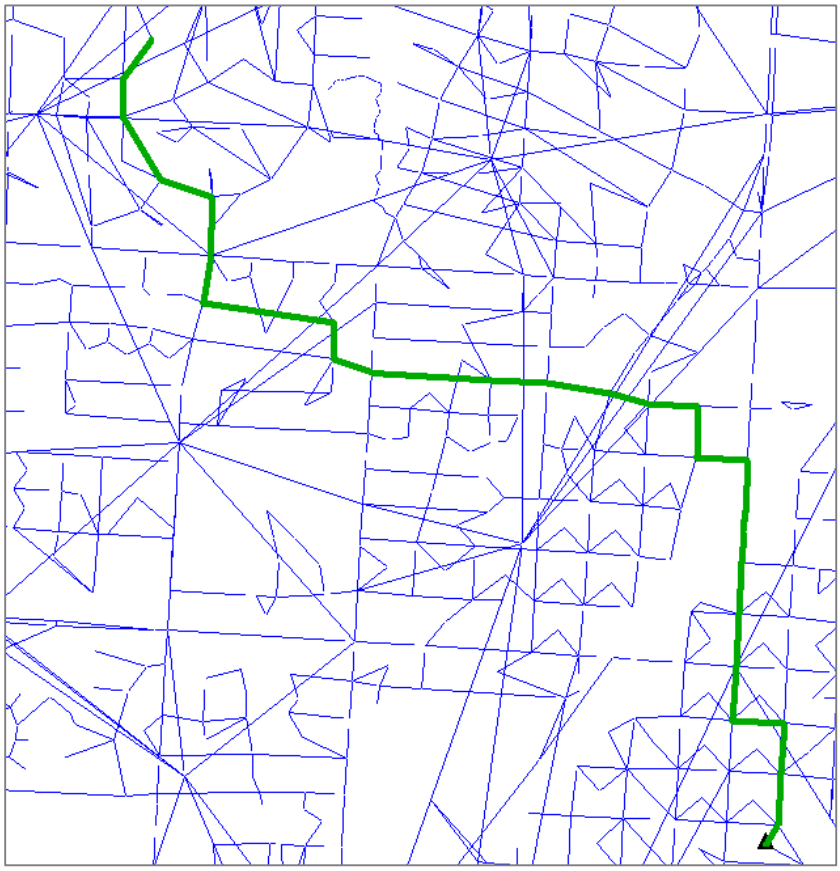
3 Non-Motorized Skims

3.1 Pedestrian and Bike MAZ-MAZ and MAZ-TAP, Bike TAZ-TAZ, Ped TAP-TAP

The non-motorized skims are built using Cube's built-in point-to-point shortest path procedure (FUNCTION=BUILDPATH), with a maximum distance of 3 miles for all skims except bike TAZ-TAZ (which has no effective limit) and pedestrian TAP-TAP, which has a 0.5 mile limit.

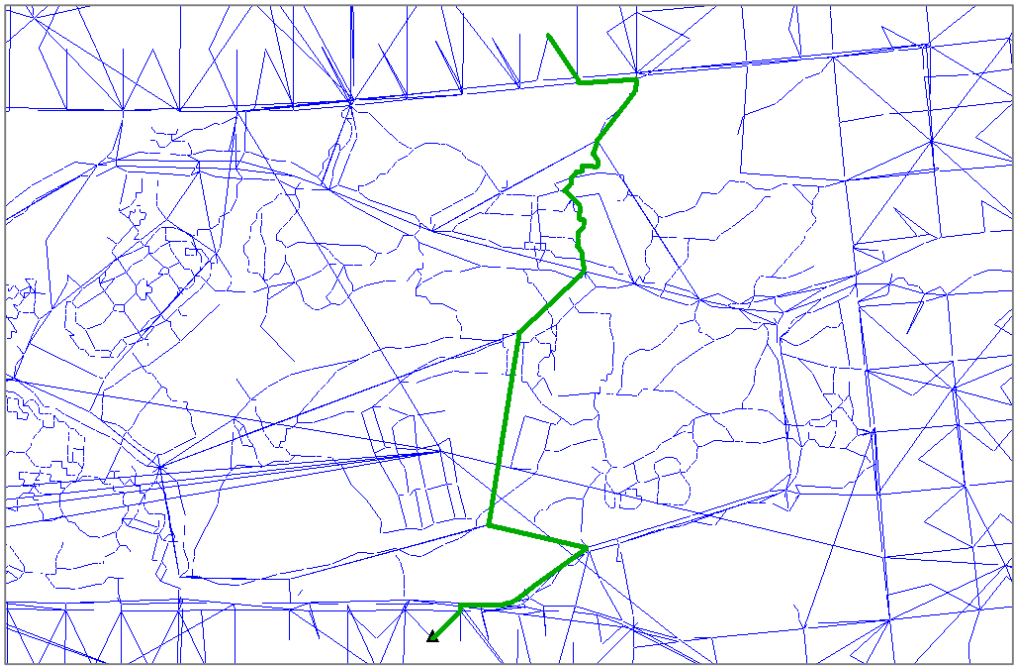
For a reasonableness check, the shortest path between a few zone pairs was calculated using Cube's interactive procedure. For each specific check, the same parameters, constraints, and networks were used as with the actual skim.

Figure 1: Shortest Pedestrian Path from MAZ 514936 to MAZ 518648



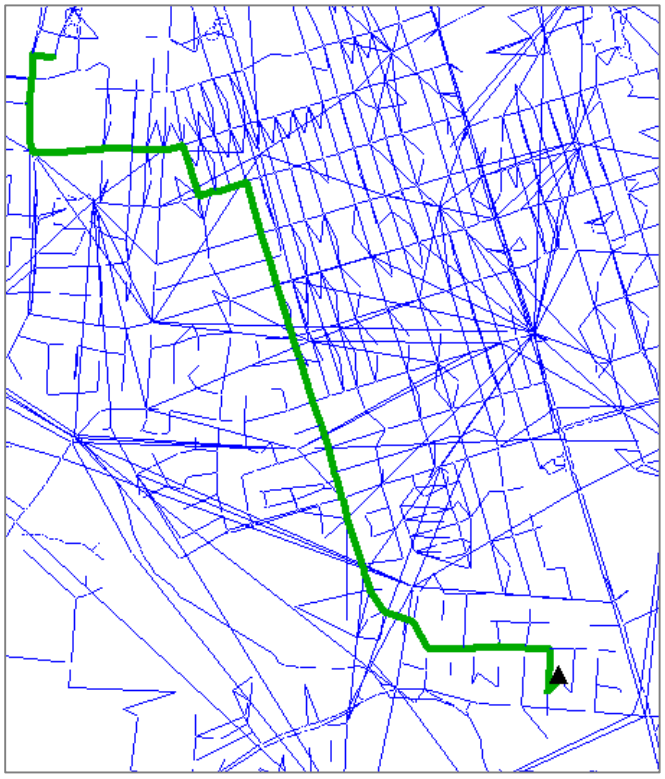
The image above shows the pedestrian shortest path from MAZ 514936 to MAZ 518648. This was a test to ensure that the path in an urban/suburban area is direct and reasonable, which it is.

Figure 2: Shortest Pedestrian Path from MAZ 10775 to MAZ 10767



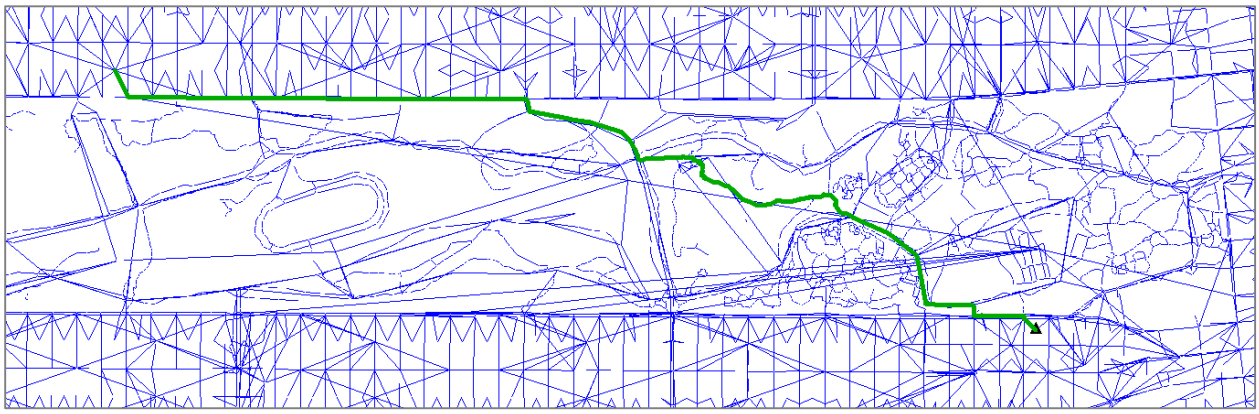
The image above shows the pedestrian shortest path from MAZ 10775 to MAZ 10767. These two zones are separated by Golden Gate Park, which is full of pedestrian links, and the shortest path shows that the procedure will uses these walk links when available.

Figure 3: Shortest Bicycle Path from MAZ 211364 to MAZ 216486



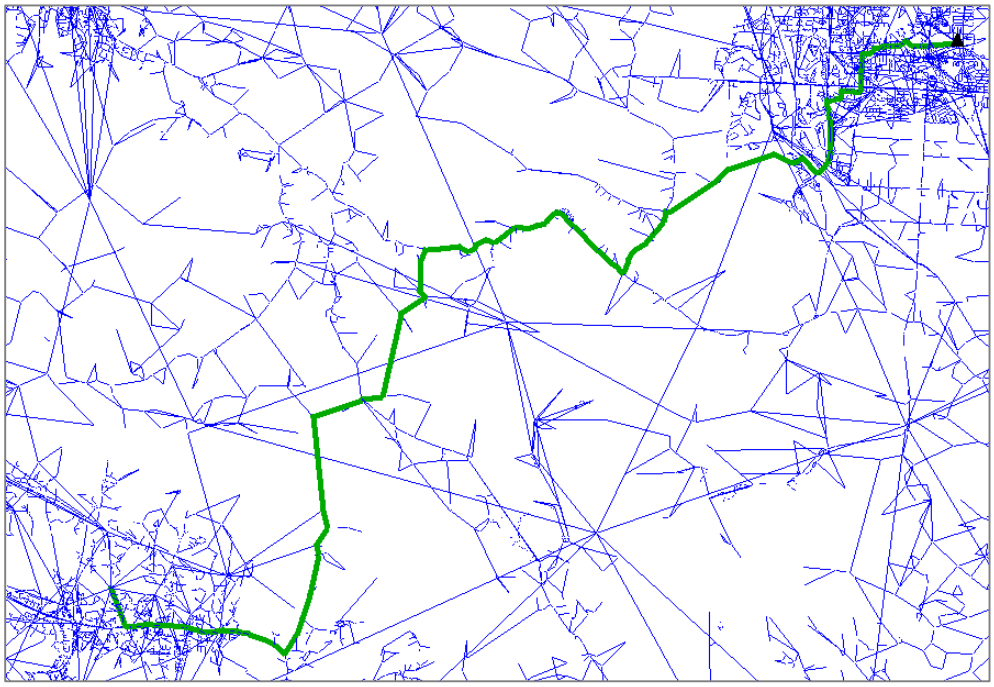
The image above shows the bicycle shortest path from MAZ 211364 to MAZ 216486. These two zones are within a suburban area which is filled with lots of network detail (including many zone connectors which should not be used). The path is straight and does not use any disallowed links.

Figure 4: Shortest Bicycle Path from MAZ 10775 to MAZ 15722



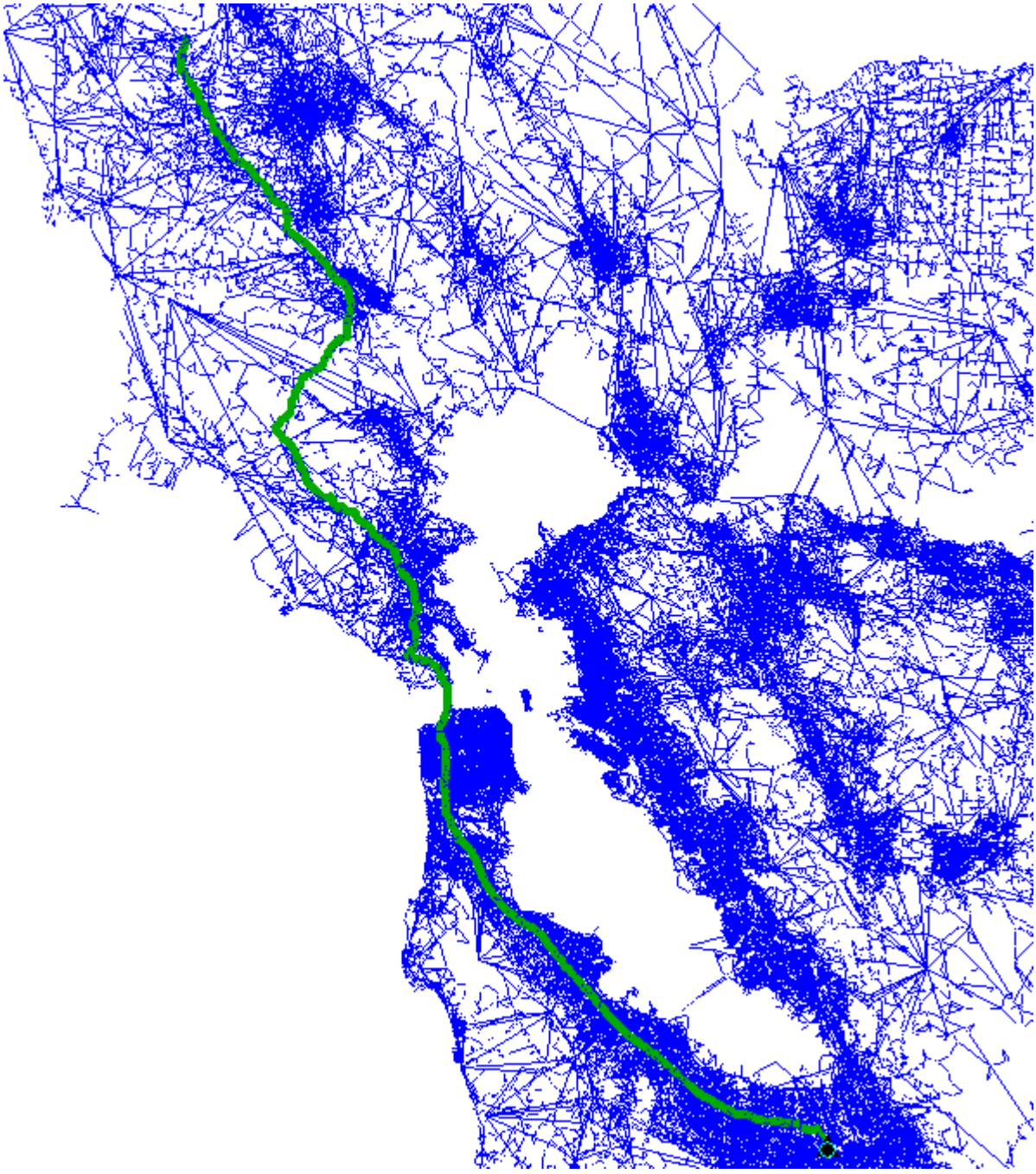
The image above shows the bicycle shortest path from MAZ 10775 to MAZ 15722. These two zones are on opposite ends of Golden Gate Park and the shortest path shows a reasonable usage of non-motorized (pedestrian and/or bike path) links through the park.

Figure 5: Shortest Bicycle Path from TAZ 400113 to TAZ 400166



The image above shows the bicycle shortest path from TAZ 400113 to TAZ 400166. The TAZ-TAZ skims are used for longer-distance bicycle trips and this path shows the long distance bike trip to be sensible and using only valid network links.

Figure 6: Shortest Bicycle Path from TAZ 200879 to TAZ 700165



The above image shows the bicycle shortest path from TAZ 200879 to TAZ 700165. These two zones are at opposite ends of the region, and the observed path is reasonable, including the use of the Golden Gate Bridge to cross the Bay.

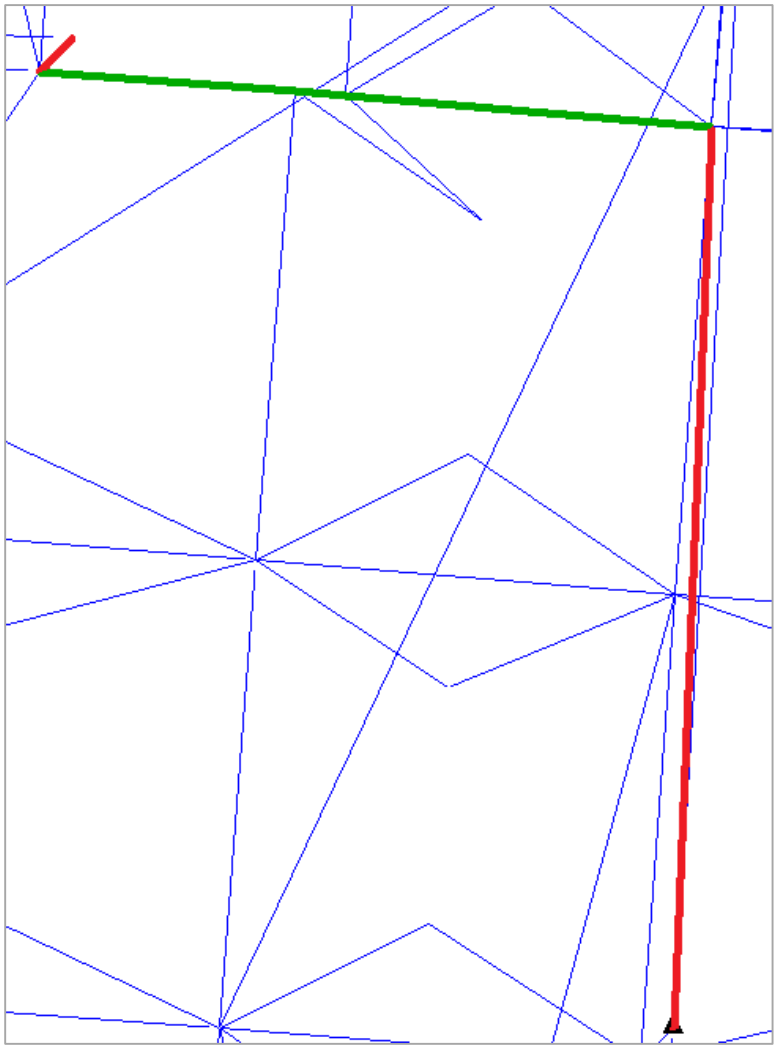
The table below summarizes the various skims in a variety of ways. Included in the summaries are comparisons between the skimmed distances and the straight-line (Euclidean) distances between the zones. Also, a comparison of how many zone pairs are within the maximum distance buffer (using both skim and Euclidean distance) is made.

Table 14 : Non-Motorized Skim Summaries

	Pedestrian			Bicycle		
	MAZ-MAZ	**MAZ-TAP**	**TAP-TAP**	**MAZ-MAZ**	**MAZ-TAP**	**TAZ-TAZ**
Max Buffer (feet)	15,840	15,840	2,640	15,840	15,840	1,500,000
Average Skimmed:Euclidean Distance Ratio	1.30	1.18	0.66	1.32	1.20	1.68
Minimum Skimmed:Euclidean Distance Ratio	0.02	0.0037	0.00056	0.02	0.00	0.014
Maximum Skimmed:Euclidean Distance Ratio	45.48	74.83	57.01	45.85	74.83	21.33
Total Zone Pairs	1,582,846,225	186,512,080	38,613,796	1,582,846,225	247,223,990	21,977,344
Total Zone Pairs Within Skimmed Max Buffer	23,570,129	4,189,525	57,639	23,024,480	4,088,264	21,935,178
% of Zone Pairs Within Skim Max Buffer	1.49%	2.25%	0.15%	1.45%	1.65%	99.81%
Total Zone Pairs Within Euclidean Max Buffer	38,021,377	12,464,971	59,600	38,021,377	12,464,971	21,977,344
Ratio of Skimmed:Euclidean Within Max Buffer	0.62	0.34	0.97	0.61	0.33	1.00

It is summarized above that the skim distance is 20-30% longer than the Euclidean distance for MAZ-MAZ and MAZ-TAP skims, which is reasonable. TAZ-TAZ (bike) skims are, on average 60% longer, which is also reasonable as TAZ connectors tend to be longer than MAZ connectors, causing a greater separation between paths. The TAP-TAP paths are on average *shorter* than the straight-line distances because TAPs often represent more than one route stop and TAP pairs may have network connectors that enter the network closer together than the TAPs themselves. The picture below shows an example of this for the shortest walk path from TAP 590002 to TAP 590244. The green portion of the path is the link walk distance, whereas the red portion is the connectors. It is shown below that the green portion is significantly shorter than the Euclidean distance between the TAPs.

Figure 7: Pedestrian Shortest Path from TAP 590002 to TAP 590244
(path TAP connectors are red and pedestrian network path links are green)



Given the small distance buffer for MAZ and TAP skims, only a small percentage of zone pairs have skim values. On the other hand, the TAZ bicycle skims, which have a very large distance limit, cover nearly all zone pairs.

4 Airport Trips

The airport trips model uses trip data/forecasts for 2007 and 2035, stratified by a wide variety of modes and the major regional airports. A simple linear interpolation is used to calculate the trips for the year being modeled, after which the trips are aggregated to the standard MTC modes. The following table shows the trips by mode for each airport (San Francisco (SFO), Oakland (OAK), and San Jose (SJC)). The airport demand model assumes there will be no tolls trips.

Table 15 : Airport Model Trips by Mode and Airport

	SFO		OAK		SJC		Total	
Mode	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Drive Alone	10,165	10,084	9,114	9,338	5,881	5,963	25,160	25,385
Shared Ride 2	8,081	8,140	6,464	6,538	4,418	4,555	18,963	19,233
Shared Ride 3+	5,565	5,662	2,753	2,477	1,603	1,405	9,921	9,544
Drive Alone Toll	-	-	-	-	-	-	-	-
Shared Ride 2 Toll	-	-	-	-	-	-	-	-
Shared Ride 3+ Toll	-	-	-	-	-	-	-	-
Total	23,810	23,885	18,331	18,353	11,902	11,923	54,044	108,205

The following charts show a distance and time distribution of trips by airport (departure and arrival are aggregated). It is noted that the distributions have a reasonable shape (skewing towards 10-20 mile trips) while still being distinct from one another.

Figure 8: Trip Distance Distribution for Airport Trips

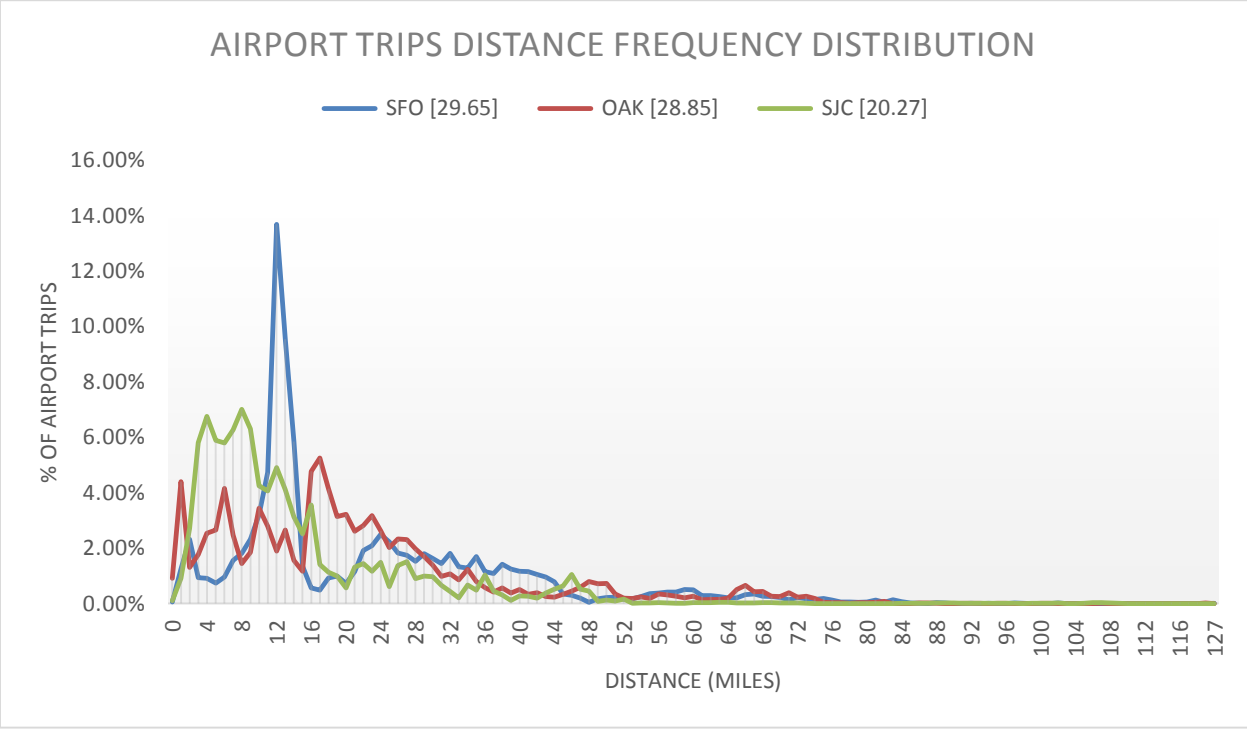
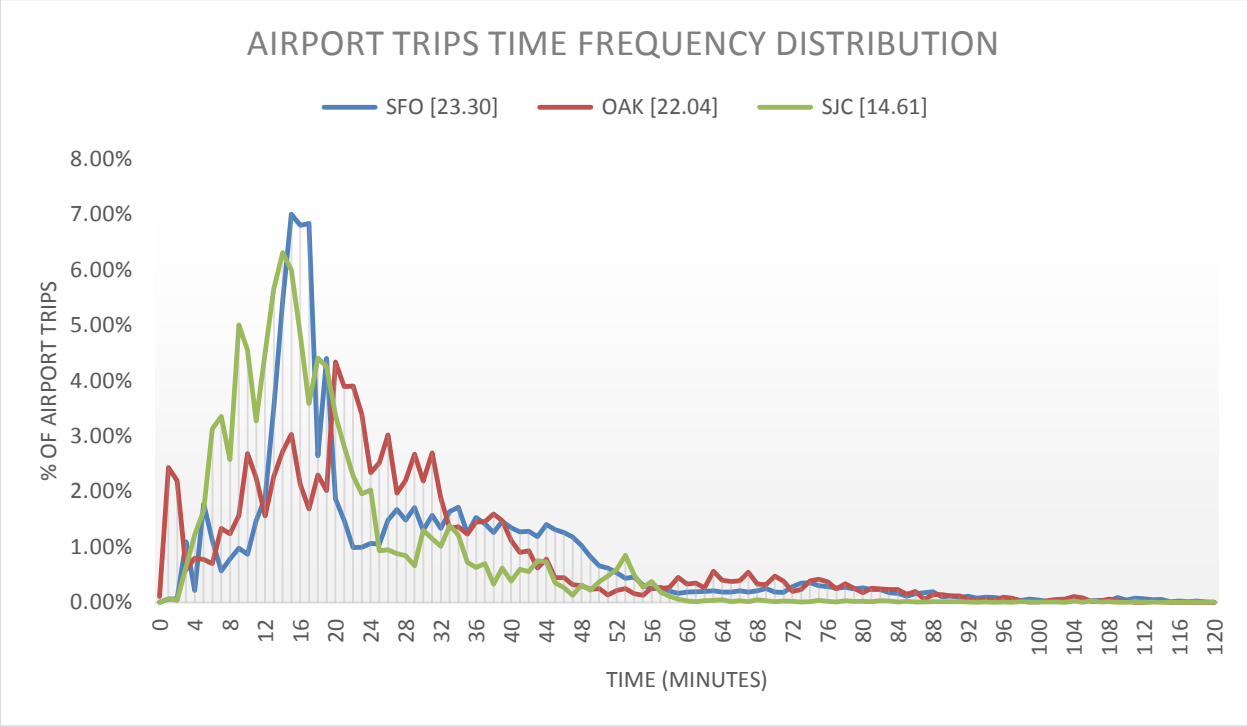


Figure 9: Trip Time Distribution for Airport Trips



5 Motorized Skims

5.1 MAZ-MAZ

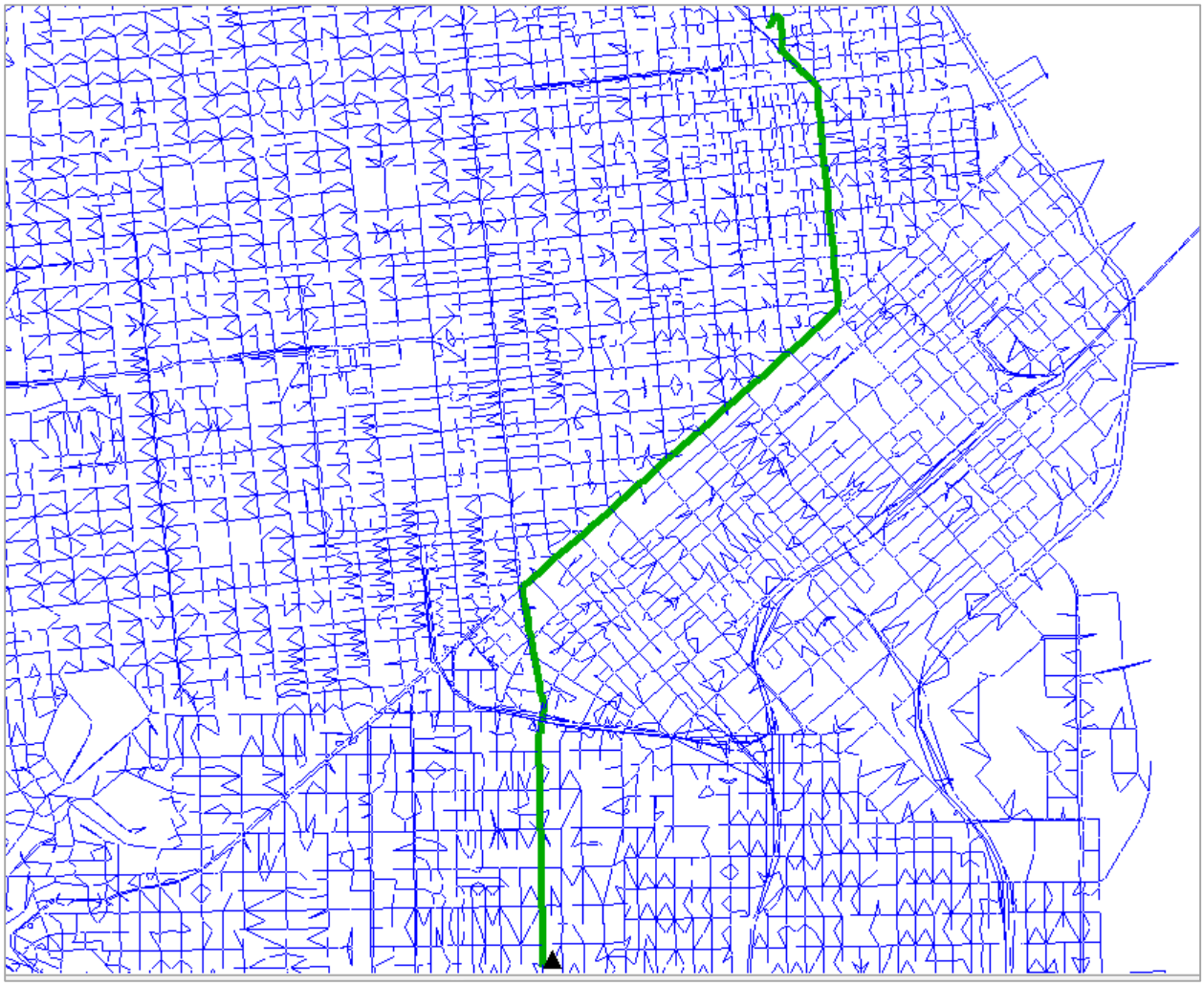
The MAZ-MAZ skims are built using Cube's built-in point-to-point shortest path procedure, using an approximate maximum distance of 5 miles (at 40 mph; the shortest path cost is actually generalized cost). The skims are all drive-alone midday period and include distance and bridge toll.

As a reasonableness check, shortest paths were built using Cube's built-in interactive procedure using the same settings and network as the actual MAZ-MAZ skims.

Figure 10: Drive Shortest Path for MAZ 328837 to MAZ 329032

The image above image shows the auto shortest path from MAZ 328837 to MAZ 329032. These two zones are close to each other and near the Bay Bridge toll plaza, which includes a lot of links which should not be used. The path does not use any of these links, and is a sensible path.

Figure 11: Drive Shortest Path for MAZ 12400 to MAZ 12303



The image above shows the auto shortest path from MAZ 12400 to MAZ 12303. These two zones are in the heart of San Francisco which contains a lot of network detail, including many zone connectors which should not be used (except at the path ends). As shown, the shortest path is straight, sensible, and avoids any of the unneeded network links.

As a further verification of the skim, the following table presents a comparison of the straight-line (Euclidean) and calculated skim distances, a summary of bridge tolls, and an analysis of zone pairs with actual skim values. It is seen that the skim values are, on average, 40% longer than the Euclidean distance between the zones, which is sensible. Also, just under 2% of all possible zone pairs have actual skim values, which is expected given the small buffer. The constant non-zero bridge toll may or may not be a bug; further testing is needed.

Table 16 : Comparison of MAZ to MAZ Euclidean and Motorized Skimmed Distances

	MAZ-MAZ
Max Buffer (miles)	~5
Average [Skimmed:Euclidean] Distance Ratio	1.39
Minimum [Skimmed:Euclidean] Distance Ratio	0.79
Maximum [Skimmed:Euclidean] Distance Ratio	130.61
Total Zone Pairs	4,387,075,225
Total Zone Pairs Within Skimmed Max Buffer	73,527,170
% of Zone Pairs Within Skimmed Max Buffer	1.68%
Total Zone Pairs Within Euclidean Max Buffer	178,912,221
Ratio of Skimmed:Euclidean Within Max Buffer	0.41
Total Zone Pairs With Non-Zero Bridge Toll	0
Average (Non-Zero) Bridge Toll	0

5.2 TAZ-TAZ

The TAZ-TAZ motorized skims are built using Cube's HIGHWAY procedure, with a separate skim being generated for each time period and mode (auto and truck types included). Skims are gathered on a variety of measures, including time, distance, and tolls.

The table below summarizes the TAZ-TAZ skims for both auto and truck modes; the summaries include average time and distance (and maximum and minimum values), as well as the percentage of all paths that contain a bridge toll (all TAZ-TAZ pairs are skimmed). These skims were performed after a model feedback iteration and thus include network congestion.

It is shown that the PM period exhibits significant congestion, and the EA, AM, and MD periods also show some congestion (at least compared to the EV period, which has the shortest travel times). The travel times and distances are reasonably distributed across the modes and time periods, with no significant outliers or anomalies, indicating that the skims are not incorrectly configured or producing erroneous results.

The percentage of paths which include bridge tolls is reasonable. There is some variation of the paths with bridge tolls across the time periods and modes, but it is difficult to discern exactly how congestion and bridge tolls affect paths aggregately; however, this phenomenon may need to be investigated further.

Table 17 : TAZ to TAZ Motorized Skim Summaries by Mode and Time Period

Mode	Skim	EA	AM	MD	PM	EV
Drive Alone	Average Time	40.89	41.05	40.89	40.96	40.89
	(min,max,sd)	(0.02 , 187.51 , 590.99)	(0.02 , 187.52 , 594.58)	(0.02 , 187.51 , 590.99)	(0.02 , 190.82 , 594.60)	(0.02 , 187.51 , 590.99)
	Average Distance	48.57	50.18	48.57	49.60	48.57
	(min,max,sd)	(0.04 , 263.13 , 766.00)	(0.04 , 263.15 , 767.23)	(0.04 , 263.13 , 766.00)	(0.04 , 266.37 , 784.23)	(0.04 , 263.13 , 766.00)
	% Zone Pairs with Bridge Toll	24.18	23.04	24.18	23.03	24.18
Shared Ride 2	Average Time	48.44	49.78	48.44	49.41	48.44
	(min,max,sd)	(0.04 , 252.20 , 758.23)	(0.04 , 252.20 , 758.16)	(0.04 , 252.20 , 758.23)	(0.04 , 263.13 , 773.92)	(0.04 , 252.20 , 758.23)
	Average Distance	40.80	41.03	40.80	40.85	40.80
	(min,max,sd)	(0.02 , 187.51 , 586.13)	(0.02 , 187.51 , 589.61)	(0.02 , 187.51 , 586.13)	(0.02 , 187.51 , 588.31)	(0.02 , 187.51 , 586.13)
	% Zone Pairs with Bridge Toll	25.65	20.51	25.65	22.15	25.65
Shared Ride 3+	Average Time	48.41	49.74	48.41	49.33	48.41
	(min,max,sd)	(0.04 , 252.20 , 755.98)	(0.04 , 252.20 , 755.07)	(0.04 , 252.20 , 755.98)	(0.04 , 257.20 , 770.74)	(0.04 , 252.20 , 755.98)
	Average Distance	40.78	40.94	40.78	40.76	40.78
	(min,max,sd)	(0.02 , 187.51 , 584.82)	(0.02 , 187.51 , 587.43)	(0.02 , 187.51 , 584.82)	(0.02 , 187.51 , 584.77)	(0.02 , 187.51 , 584.82)
	% Zone Pairs with Bridge Toll	26.27	21.92	26.27	24.03	26.27
Very Small Truck	Average Time	48.39	50.04	48.39	49.42	48.39
	(min,max,sd)	(0.04 , 252.20 , 755.36)	(0.04 , 252.49 , 758.15)	(0.04 , 252.20 , 755.36)	(0.04 , 257.49 , 771.64)	(0.04 , 252.20 , 755.36)
	Average Distance	40.86	40.98	40.86	40.89	40.86
	(min,max,sd)	(0.02 , 187.51 , 587.11)	(0.02 , 187.52 , 590.39)	(0.02 , 187.51 , 587.11)	(0.02 , 187.52 , 588.60)	(0.02 , 187.51 , 587.11)
	% Zone Pairs with Bridge Toll	25.88	24.54	25.88	24.94	25.88
Small Truck	Average Time	48.39	50.04	48.39	49.42	48.39
	(min,max,sd)	(0.04 , 252.20 , 755.36)	(0.04 , 252.49 , 758.15)	(0.04 , 252.20 , 755.36)	(0.04 , 257.49 , 771.64)	(0.04 , 252.20 , 755.36)
	Average Distance	40.86	40.98	40.86	40.89	40.86
	(min,max,sd)	(0.02 , 187.51 , 587.11)	(0.02 , 187.52 , 590.39)	(0.02 , 187.51 , 587.11)	(0.02 , 187.52 , 588.60)	(0.02 , 187.51 , 587.11)
	% Zone Pairs with Bridge Toll	25.88	24.54	25.88	24.94	25.88
Medium Truck	Average Time	48.42	50.06	48.42	49.44	48.42
	(min,max,sd)	(0.04 , 252.20 , 757.19)	(0.04 , 252.49 , 759.76)	(0.04 , 252.20 , 757.19)	(0.04 , 263.15 , 773.17)	(0.04 , 252.20 , 757.19)
	Average Distance	40.89	41.01	40.89	40.93	40.89
	(min,max,sd)	(0.02 , 187.51 , 589.38)	(0.02 , 187.52 , 592.18)	(0.02 , 187.51 , 589.38)	(0.02 , 187.52 , 590.84)	(0.02 , 187.51 , 589.38)
	% Zone Pairs with Bridge Toll	25.35	24.13	25.35	24.43	25.35
Large Truck	Average Time	48.65	50.26	48.65	49.61	48.65
	(min,max,sd)	(0.04 , 266.17 , 775.96)	(0.04 , 265.36 , 776.84)	(0.04 , 266.17 , 775.96)	(0.04 , 265.36 , 786.56)	(0.04 , 266.17 , 775.96)
	Average Distance	41.02	41.23	41.02	41.08	41.02
	(min,max,sd)	(0.02 , 190.79 , 597.09)	(0.02 , 192.36 , 601.01)	(0.02 , 190.79 , 597.09)	(0.02 , 192.36 , 598.98)	(0.02 , 190.79 , 597.09)
	% Zone Pairs with Bridge Toll	23.14	21.84	23.14	22.48	23.14

As a further check on the correctness of the highway skims, a selection of "landmark" TAZs was selected and the skim results compared to those calculated by the Google Maps service. To avoid being skewed by congestion effects, the EA time period skims were used for this analysis.

The landmark TAZs that were selected are those associated with Coit Tower; San Francisco International Airport (SFO); Oakland International Airport (OAK); San Jose International Airport (SJC); the Gilroy Public Library; the Concord Waterworld water park; and Santa Rosa Junior College campus in Santa Rosa (SRJC).

The results of these comparisons are presented in the tables below; the tables present OD results for the Google Maps and skims, as well as the percentage difference between the two. Time and distance comparisons are shown, in that order. The difference table cells are colored based on how much over/under (green/red) the skims are with respect to Google.

Overall, the results are reasonable, in particular the distance results which are very close. This indicates that the network geometry and generated paths are probably accurate. The times are also within reason, except for a few outliers. Only one combination – the time from Concord Waterworld to SFO – is overestimated by the model by over 40%. It is not immediately clear what the issue might be (due to the size of the network and the complexity of the skimming procedures). This needs to be investigated in more detail.

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Table 18A: Google Maps Drive Distance between selected locations

Google Drive Distance	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		15.30	19.40	48.30	81.70	29.40	55.20
SFO	16.10		30.40	33.50	66.90	40.80	69.10
OAK	20.20	29.30		32.70	65.40	31.60	68.50
SJC	48.80	33.00	32.90		34.50	49.80	98.40
Gilroy Library	81.60	65.80	65.00	34.80		81.10	131.00
Concord Waterworld	29.50	39.90	29.40	49.40	81.20		63.00
SRJC	55.30	68.00	67.90	98.10	131.00	59.90	

Table 18B: Drive Skim Distance between selected locations

Drive Skim Distance	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		13.37	18.15	47.36	80.09	28.73	55.42
SFO	14.22		29.67	33.20	65.93	38.74	67.78
OAK	17.95	29.63		34.92	64.62	24.60	66.93
SJC	47.91	33.74	36.93		35.72	51.14	101.47
Gilroy Library	80.61	66.45	66.27	35.95		79.58	136.13
Concord Waterworld	28.39	38.57	26.93	52.66	80.64		59.31
SRJC	55.14	67.26	66.13	100.78	130.48	58.53	

Table 18C: Percent Difference between Google Maps and Skim Drive Distances [2]

Percent Difference	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		-12.6%	-6.4%	-2.0%	-2.0%	-2.3%	0.4%
SFO	-11.7%		-2.4%	-0.9%	-1.5%	-5.1%	-1.9%
OAK	-11.1%	1.1%		6.8%	-1.2%	-22.1%	-2.3%
SJC	-1.8%	2.2%	12.3%		3.5%	2.7%	3.1%
Gilroy Library	-1.2%	1.0%	2.0%	3.3%		-1.9%	3.9%
Concord Waterworld	-3.8%	-3.3%	-8.4%	6.6%	-0.7%		-5.9%
SRJC	-0.3%	-1.1%	-2.6%	2.7%	-0.4%	-2.3%	

[2] This table and Table 19C uses a diverging color scheme with overestimates (modelled distance greater than observed distance) shown in increasing shades of red while underestimates – (modelled distance lesser than observed distance) shown in increasing shades of green.

Table 19A: Google Maps Drive Time between selected locations

Google Drive Time	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		25.00	33.00	56.00	91.00	41.00	67.00
SFO	28.00		37.00	34.00	70.00	50.00	79.00
OAK	34.00	31.00		38.00	66.00	39.00	71.00
SJC	64.00	33.00	37.00		35.00	55.00	113.00
Gilroy Library	93.00	63.00	64.00	34.00		78.00	125.00
Concord Waterworld	41.00	44.00	33.00	52.00	77.00		67.00
SRJC	63.00	74.00	69.00	106.00	136.00	69.00	

Table 19B: Drive Skim Time between selected locations

Drive Skim Time	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		19.29	28.87	58.63	93.80	40.19	79.08
SFO	18.50		36.26	43.28	78.45	50.56	95.50
OAK	44.95	43.82		43.86	76.08	34.44	89.79
SJC	60.10	41.73	46.38		42.73	53.13	137.10
Gilroy Library	95.89	77.52	78.57	43.32		80.85	166.41
Concord Waterworld	57.84	68.59	34.72	58.00	86.65		92.54
SRJC	76.36	92.83	84.02	122.14	154.36	88.30	

Table 19C: Percent Difference between Google Maps and Skim Drive Times

Percent Difference	Coit Tower	SFO	OAK	SJC	Gilroy Library	Concord Waterworld	SRJC
Coit Tower		-22.8%	-12.5%	4.7%	3.1%	-2.0%	18.0%
SFO	-33.9%		-2.0%	27.3%	12.1%	1.1%	20.9%
OAK	32.2%	41.4%		15.4%	15.3%	-11.7%	26.5%
SJC	-6.1%	26.5%	25.4%		22.1%	-3.4%	21.3%
Gilroy Library	3.1%	23.1%	22.8%	27.4%		3.7%	33.1%
Concord Waterworld	41.1%	55.9%	5.2%	11.5%	12.5%		38.1%
SRJC	21.2%	25.5%	21.8%	15.2%	13.5%	28.0%	

5.3 TAZ-TAP

The TAZ-TAP skims are used for drive-to-transit calculations, and are built using a combination of TAZ-TAZ drive skims and MAZ-TAP pedestrian skims (with the TAZ-MAZ mapping provided via the zonal data file). The final skims are segmented by transit mode and time period, and include drive distance, time, and toll, as well as walk distance.

The table below summarized the TAZ-TAP skims for the five different transit modes. Summaries are recorded for drive distance and time, walk distance, and bridge tolls; average values, as well as maximum and minimum are presented. All of the values are reasonable, and it is seen that the drive times/distances are longer for the non-local bus modes than local bus mode, which is expected as they have less coverage across the region (and to access them, one would need to travel further). The walk distances are all about a quarter mile or less, which is sensible. Also, paths to premium rail service includes bridge tolls in some cases. This makes sense as people would be willing to drive out further to access better transit services as can be seen from the average drive times and distances to the different services and a longer drive time has a higher probability of picking up a toll on the path.

Table 20 : TAZ-TAP Skim Summaries by Mode and Time Period

	Average Skim (min,max)	EA	AM	MD	PM	EV
Local Bus	**Drive Time (minutes)**	1.63 (0.07 , 83.03)	1.63 (0.07 , 83.03)	1.63 (0.07 , 83.03)	1.63 (0.07 , 83.03)	1.63 (0.07 , 83.03)
	Drive Distance (miles)	0.71 (0.03 , 45.08)	0.71 (0.03 , 45.08)	0.71 (0.03 , 45.08)	0.71 (0.03 , 45.08)	0.71 (0.03 , 45.08)
	Toll (cents)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)
	Walk Distance (feet)	228.06 (13.94 , 1592.39)	228.15 (13.94 , 1592.39)	228.05 (13.94 , 1592.39)	228.78 (13.94 , 1592.39)	227.99 (13.94 , 1592.39)
Express Bus	**Drive Time (minutes)**	8.29 (0.06 , 142.91)	8.28 (0.06 , 142.91)	8.28 (0.06 , 142.91)	8.31 (0.06 , 142.91)	8.27 (0.06 , 142.91)
	Drive Distance (miles)	5.04 (0.02 , 82.07)	5.04 (0.02 , 82.07)	5.05 (0.02 , 82.07)	5.04 (0.02 , 82.07)	5.05 (0.02 , 82.07)
	Toll (cents)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)
	Walk Distance (feet)	288.10 (14.71 , 1179.44)	284.15 (14.71 , 1179.44)	285.11 (14.71 , 1179.44)	285.02 (14.71 , 1179.44)	284.25 (14.71 , 1179.44)
Light Rail/Ferry	**Drive Time (minutes)**	21.70 (0.13 , 172.67)	28.42 (0.13 , 172.67)	23.44 (0.13 , 172.67)	21.46 (0.13 , 172.67)	21.74 (0.13 , 172.67)
	Drive Distance (miles)	17.78 (0.06 , 108.56)	24.73 (0.06 , 108.56)	19.62 (0.06 , 108.56)	17.49 (0.06 , 108.56)	17.76 (0.06 , 108.56)
	Toll (cents)	140.80 (0.00 , 402.00)	47.81 (0.00 , 402.00)	111.15 (0.00 , 402.00)	149.92 (0.00 , 402.00)	142.44 (0.00 , 402.00)
	Walk Distance (feet)	306.91 (15.21 , 1087.44)	281.95 (15.21 , 1087.44)	228.59 (15.21 , 1087.44)	310.23 (15.21 , 1087.44)	272.31 (15.21 , 1087.44)
Heavy Rail	**Drive Time (minutes)**	17.96 (0.08 , 166.55)	17.95 (0.08 , 166.55)	17.94 (0.08 , 166.55)	20.58 (0.08 , 199.38)	17.94 (0.08 , 166.55)
	Drive Distance (miles)	13.52 (0.03 , 102.89)	13.45 (0.03 , 102.89)	13.53 (0.03 , 102.89)	14.47 (0.03 , 114.68)	13.53 (0.03 , 102.89)
	Toll (cents)	0.09 (0.00 , 402.00)	0.00 (0.00 , 0.00)	0.51 (0.00 , 402.00)	16.55 (0.00 , 402.00)	0.00 (0.00 , 0.00)
	Walk Distance (feet)	195.92 (42.16 , 1060.44)	193.95 (42.16 , 1060.44)	193.57 (42.16 , 1060.44)	201.85 (42.16 , 1060.44)	191.72 (42.16 , 1060.44)
Commuter Rail	**Drive Time (minutes)**	14.24 (0.09 , 166.55)	14.25 (0.09 , 166.55)	14.23 (0.09 , 166.55)	16.67 (0.09 , 194.52)	14.23 (0.09 , 166.55)
	Drive Distance (miles)	9.37 (0.04 , 102.89)	9.35 (0.04 , 102.89)	9.35 (0.04 , 102.89)	9.91 (0.04 , 110.35)	9.37 (0.04 , 102.89)
	Toll (cents)	0.00 (0.00 , 0.00)	0.00 (0.00 , 0.00)	0.09 (0.00 , 402.00)	13.63 (0.00 , 402.00)	0.00 (0.00 , 0.00)
	Walk Distance (feet)	277.29 (68.74 , 1535.85)	276.98 (68.74 , 1535.85)	279.11 (68.74 , 1535.85)	299.57 (68.74 , 1535.85)	277.09 (68.74 , 1535.85)

6 Transit Skims

The TAP-TAP transit skims are built using Cube's PUBLIC TRANSPORT program, are segmented by time period. Three sets of skims are created:

1. Set 1 - local bus only,
2. Set 2 - all modes, and
3. Set 3 - all modes with a high transfer penalty weight.

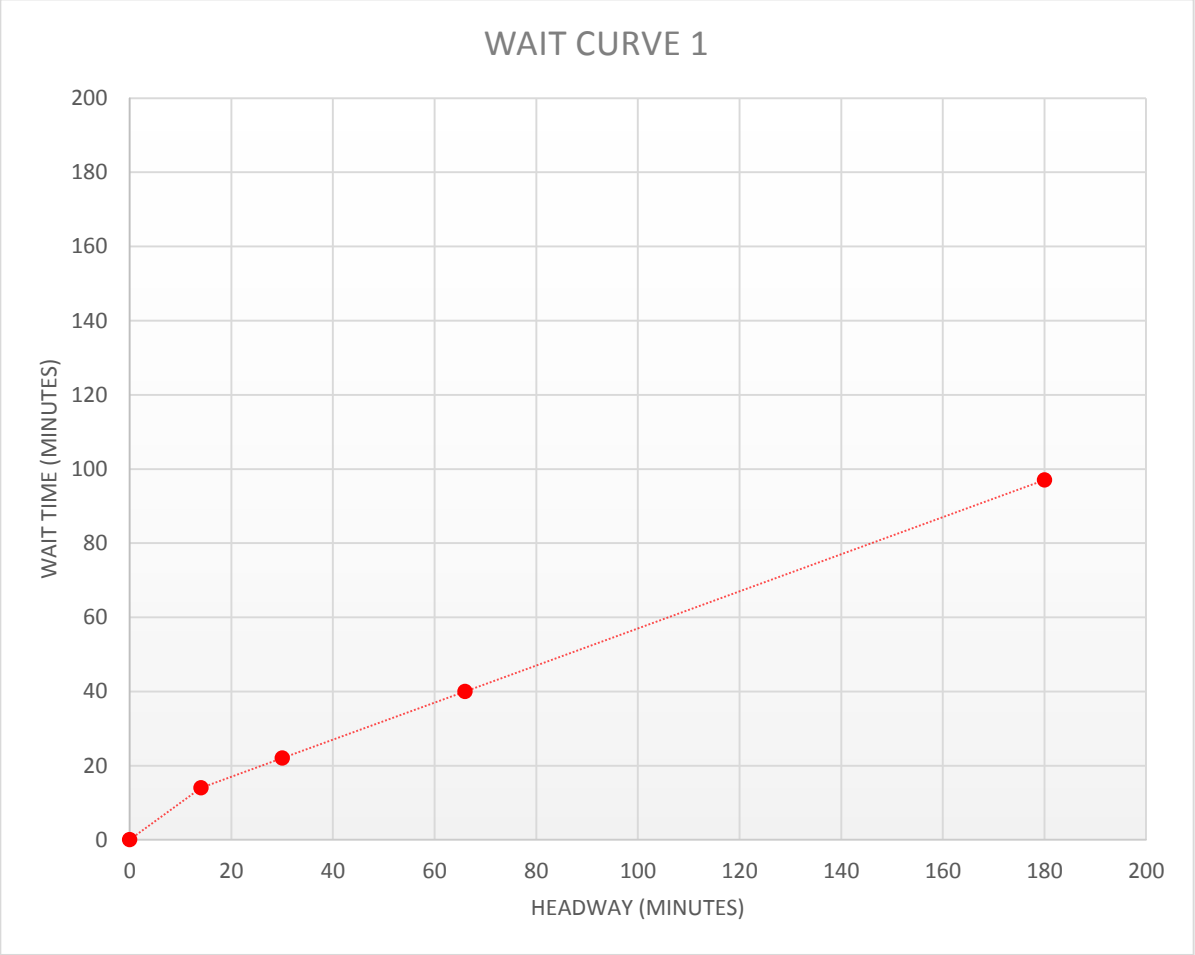
The specific settings used in the skimming procedure is shown below:

Table 21 : Transit Skim Settings

	SET1		SET2		SET3	
	Value	**Weight**	**Value**	**Weight**	**Value**	**Weight**
Boarding	3 min	1	3 min		3 min	
RUNFACTOR	NA		0.75 [Premium] 1.00 [Local]		0.75 [Premium] 1.00 [Local]	
Transfer penalty	5 min	1	5 min	1	5 min	3
Max Transfers	3		3		3	
Fare	Fare matrix	10	Fare matrix	10	Fare matrix	10
Max path cost	600		600		600	
Wait Times						
Initial Wait	Curve 1	1	Curve 1	1	Curve 1	1
Transfer Wait	Curve 1	1	Curve 1	1	Curve 1	1

The wait curve referred to in the table above is implemented as shown below – it computes wait time as a function of headway. The curve is non-linear since the wait time for a 14 minute headway is 14 minutes, whereas a 66 minute headway has a 40 minute wait. The functions used to transform headway into wait times obviously impact route choice and will be further reviewed and/or revised during model calibration.

Figure 12: Transit Skim Settings



Walk transfers are done via virtual walk links coded between stops. The distance on these links are coded based on the straight line distance – walk time is calculated assuming a walk speed of 3 mph. The tables below summarize the TAP-TAP skims for the three transit skim sets. Summaries for multiple skim variables are included, with average, maximum, and minimum values reported. For all three skims, the values are generally reasonable and consistent across time periods. We can see that an average fare of ~$2.00 is applied to SET1 (local only skims) while a fare of ~$6.00 is applied to SET2 and SET3 (Premium on path). These are representative of the transit fares in the Bay Area. Also, in the peak periods, SET1 has a coverage of TAP pair coverage of 20% while SET2 and SET3 has a TAP pair coverage of about 45%. We can also see that the AM and PM connectivity is higher than the off-peak connectivity as there are more services in those periods – this indicates that the time-of-day specific transit network coding is being done correctly.

The share of paths between different technology also seems reasonable – as per the skimming procedure - local bus service is the most popular option (this could be owed to its coverage) followed by heavy rail and then by express bus. Based on the positive share for all modes we can be sure that all modes are being used in path building.

Table 22: TAP-TAP SET1 Local Transit Skim Summaries by Time Period

Skim	EA	AM	MD	PM	EV
% Zone Pairs with Transit Path	11.83	20.68	17.78	20.15	19.30
Composite Cost (mean)	209.64	176.07	175.94	175.75	201.55
(min,max,sd)	(6.90 , 599.96 , 11582.81)	(4.24 , 598.94 , 7980.60)	(4.67 , 614.79 , 8211.43)	(4.37 , 613.18 , 7950.60)	(5.38 , 600.00 , 11357.96)
Initial Wait (mean)	27.96	19.66	20.99	19.08	23.97
(min,max,sd)	(2.92 , 37.00 , 88.82)	(0.71 , 37.00 , 91.40)	(1.15 , 37.00 , 92.83)	(0.85 , 37.00 , 83.86)	(1.86 , 37.00 , 109.77)
Transfer Wait (mean)	55.29	39.66	41.86	39.99	48.44
(min,max,sd)	(2.92 , 111.00 , 688.35)	(0.71 , 111.00 , 408.41)	(1.15 , 111.00 , 472.36)	(0.85 , 111.00 , 403.00)	(1.86 , 111.00 , 548.67)
Transfers (mean)	2.07	2.19	2.16	2.18	2.16
(min,max,sd)	(1.00 , 3.00 , 0.63)	(1.00 , 3.00 , 0.59)	(1.00 , 3.00 , 0.59)	(1.00 , 3.00 , 0.58)	(1.00 , 3.00 , 0.59)
Fare (mean)	2.80	2.44	2.39	2.44	2.66
(min,max,sd)	(0.65 , 7.35 , 2.59)	(0.35 , 7.77 , 2.00)	(0.35 , 7.77 , 1.58)	(0.35 , 7.77 , 1.79)	(0.49 , 9.03 , 2.14)
Transfer Walk Time (mean)	3.81	4.01	4.07	4.24	3.87
(min,max,sd)	(0.19 , 33.83 , 10.86)	(0.18 , 41.77 , 11.39)	(0.18 , 39.90 , 12.05)	(0.18 , 41.77 , 12.79)	(0.18 , 34.64 , 10.59)
Access/Egress Time (mean)	0.01	0.01	0.01	0.01	0.01
(min,max,sd)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)
Local Bus IVT (mean)	107.04	94.77	91.50	94.60	108.01
(min,max,sd)	(0.03 , 450.32 , 6299.73)	(0.02 , 475.04 , 4552.07)	(0.03 , 485.88 , 4772.72)	(0.02 , 489.52 , 4870.28)	(0.02 , 490.56 , 6826.88)
Express Bus IVT (mean)	0.00	0.00	0.00	0.00	0.00
(min,max,sd)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)
Light Rail/Ferry IVT (mean)	0.00	0.00	0.00	0.00	0.00
(min,max,sd)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)
Heavy Rail IVT (mean)	0.00	0.00	0.00	0.00	0.00
(min,max,sd)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)
Commuter Rail IVT (mean)	0.00	0.00	0.00	0.00	0.00
(min,max,sd)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)	(0.00 , 0.00 , 0.00)
Best Mode (mean)	1.00	1.00	1.00	1.00	1.00
(min,max,sd)	(1.00 , 1.00 , 0.00)	(1.00 , 1.00 , 0.00)	(1.00 , 1.00 , 0.00)	(1.00 , 1.00 , 0.00)	(1.00 , 1.00 , 0.00)
% of Paths using Local Bus	11.83	20.68	17.78	20.15	19.30
% of Paths using Express Bus	0.00	0.00	0.00	0.00	0.00
% of Paths using Light Rail/Ferry	0.00	0.00	0.00	0.00	0.00
% of Paths using Heavy Rail	0.00	0.00	0.00	0.00	0.00
% of Paths using Commuter Rail	0.00	0.00	0.00	0.00	0.00

Table 23: TAP-TAP SET2 Local + Premium Transit Skim Summaries by Time Period[3]

Skim	EA	AM	MD	PM	EV
% Zone Pairs with Transit Path	26.73	46.37	41.33	45.34	39.36
Composite Cost (mean)	177.71	159.13	164.03	157.81	167.65
(min,max,sd)	(6.90 , 599.84 , 4542.96)	(4.24 , 598.90 , 4935.43)	(4.67 , 614.32 , 4762.71)	(4.37 , 599.68 , 4499.21)	(5.38 , 599.52 , 4629.15)
Initial Wait (mean)	26.64	18.89	20.61	18.76	22.65
(min,max,sd)	(2.92 , 37.00 , 95.55)	(0.71 , 37.00 , 90.41)	(1.15 , 37.00 , 96.86)	(0.85 , 37.00 , 89.73)	(1.86 , 37.00 , 105.08)
Transfer Wait (mean)	52.05	36.75	41.62	36.93	45.12
(min,max,sd)	(2.92 , 111.00 , 458.68)	(0.71 , 111.00 , 321.25)	(1.15 , 111.00 , 355.67)	(0.85 , 111.00 , 302.08)	(1.86 , 111.00 , 364.94)
Transfers (mean)	2.33	2.40	2.38	2.38	2.35
(min,max,sd)	(1.00 , 3.00 , 0.49)	(1.00 , 3.00 , 0.46)	(1.00 , 3.00 , 0.46)	(1.00 , 3.00 , 0.46)	(1.00 , 3.00 , 0.48)
Fare (mean)	6.43	6.10	6.25	6.20	6.22
(min,max,sd)	(0.57 , 35.28 , 14.69)	(0.35 , 35.42 , 12.87)	(0.35 , 37.13 , 13.70)	(0.65 , 37.13 , 13.66)	(0.49 , 33.56 , 13.34)
Transfer Walk Time (mean)	5.26	5.02	4.97	5.02	4.99
(min,max,sd)	(0.07 , 34.08 , 14.58)	(0.14 , 39.90 , 12.83)	(0.14 , 39.67 , 12.22)	(0.14 , 39.90 , 12.66)	(0.07 , 34.15 , 12.90)
Access/Egress Time (mean)	0.01	0.01	0.01	0.01	0.01
(min,max,sd)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)
Local Bus IVT (mean)	39.25	43.67	43.13	42.28	41.06
(min,max,sd)	(0.03 , 420.81 , 1563.96)	(0.02 , 472.41 , 2485.06)	(0.02 , 494.19 , 2339.74)	(0.02 , 494.20 , 2319.29)	(0.02 , 472.99 , 2216.10)
Express Bus IVT (mean)	45.44	48.97	51.87	49.37	48.24
(min,max,sd)	(0.03 , 307.04 , 1287.36)	(0.03 , 265.56 , 1093.77)	(0.19 , 250.58 , 736.73)	(0.03 , 273.22 , 1045.36)	(0.03 , 287.09 , 988.48)
Light Rail/Ferry IVT (mean)	19.54	20.67	18.96	17.86	19.14
(min,max,sd)	(0.15 , 330.86 , 567.82)	(0.15 , 272.55 , 652.80)	(0.15 , 259.60 , 507.80)	(0.15 , 260.04 , 379.77)	(0.15 , 260.04 , 534.53)
Heavy Rail IVT (mean)	42.45	42.41	42.77	42.88	42.96
(min,max,sd)	(0.66 , 103.71 , 455.85)	(0.66 , 103.71 , 446.35)	(0.66 , 103.71 , 451.41)	(0.66 , 103.71 , 451.04)	(0.66 , 103.71 , 450.25)
Commuter Rail IVT (mean)	61.48	53.15	55.87	54.72	57.22
(min,max,sd)	(2.44 , 203.86 , 744.79)	(2.39 , 223.07 , 840.22)	(2.44 , 190.06 , 790.74)	(2.39 , 207.65 , 897.86)	(2.44 , 216.82 , 804.57)
Best Mode (mean)	3.47	3.43	3.40	3.43	3.40
(min,max,sd)	(1.00 , 5.00 , 1.62)	(1.00 , 5.00 , 1.71)	(1.00 , 5.00 , 1.75)	(1.00 , 5.00 , 1.73)	(1.00 , 5.00 , 1.76)
% of Paths using Local Bus	26.34	45.96	41.09	44.97	38.95
% of Paths using Express Bus	7.40	12.43	8.81	11.49	10.01
% of Paths using Light Rail/Ferry	2.60	4.68	4.10	4.56	3.68
% of Paths using Heavy Rail	15.19	24.77	23.22	24.24	20.98
% of Paths using Commuter Rail	3.94	7.40	5.78	7.34	6.07

[3] **Note that the statistics reported in Table 23 and**

Table 24 are for non-zero values of the respective matrices.

Table 24 : TAP-TAP SET2 Local + Premium Transit Skim Summaries by Time Period

Skim	EA	AM	MD	PM	EV
% Zone Pairs with Transit Path	28.42	50.87	44.70	49.60	42.93
Composite Cost (mean)	205.33	188.34	192.62	186.62	196.07
(min,max,sd)	(6.90 , 599.97 , 5746.97)	(4.24 , 599.93 , 5852.33)	(4.67 , 614.68 , 5679.49)	(4.37 , 614.56 , 5353.61)	(5.38 , 600.00 , 5500.94)
Initial Wait (mean)	26.94	19.17	20.82	19.07	23.15
(min,max,sd)	(2.92 , 37.00 , 93.76)	(0.71 , 37.00 , 91.41)	(1.15 , 37.00 , 96.26)	(0.85 , 37.00 , 90.54)	(1.86 , 37.00 , 104.85)
Transfer Wait (mean)	52.81	37.60	42.47	37.65	46.02
(min,max,sd)	(2.92 , 111.00 , 478.71)	(0.71 , 111.00 , 332.32)	(1.15 , 111.00 , 368.87)	(0.85 , 111.00 , 313.53)	(1.86 , 111.00 , 376.62)
Transfers (mean)	2.30	2.38	2.37	2.36	2.33
(min,max,sd)	(1.00 , 3.00 , 0.51)	(1.00 , 3.00 , 0.47)	(1.00 , 3.00 , 0.47)	(1.00 , 3.00 , 0.47)	(1.00 , 3.00 , 0.49)
Fare (mean)	6.44	6.15	6.30	6.26	6.27
(min,max,sd)	(0.57 , 35.28 , 15.46)	(0.35 , 35.42 , 13.74)	(0.35 , 38.99 , 14.59)	(0.35 , 38.99 , 14.63)	(0.49 , 35.28 , 14.18)
Transfer Walk Time (mean)	5.27	5.09	5.06	5.13	4.99
(min,max,sd)	(0.07 , 34.08 , 14.93)	(0.14 , 52.92 , 13.44)	(0.14 , 39.67 , 12.85)	(0.14 , 39.94 , 13.45)	(0.07 , 35.37 , 13.00)
Access/Egress Time (mean)	0.01	0.01	0.01	0.01	0.01
(min,max,sd)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)	(0.01 , 0.02 , 0.00)
Local Bus IVT (mean)	42.48	46.88	45.74	45.07	43.58
(min,max,sd)	(0.03 , 420.68 , 1843.74)	(0.02 , 452.34 , 2665.11)	(0.02 , 473.93 , 2504.05)	(0.02 , 482.81 , 2474.12)	(0.02 , 455.76 , 2295.25)
Express Bus IVT (mean)	48.73	51.43	53.94	52.19	51.64
(min,max,sd)	(0.03 , 295.16 , 1291.50)	(0.03 , 265.56 , 1079.96)	(0.19 , 250.58 , 727.21)	(0.03 , 273.22 , 1037.91)	(0.03 , 294.88 , 986.13)
Light Rail/Ferry IVT (mean)	20.52	21.41	20.02	18.66	21.22
(min,max,sd)	(0.15 , 330.86 , 691.13)	(0.15 , 272.55 , 694.93)	(0.15 , 259.60 , 587.34)	(0.15 , 260.04 , 430.65)	(0.15 , 260.04 , 674.23)
Heavy Rail IVT (mean)	43.60	43.88	44.16	44.34	44.09
(min,max,sd)	(0.66 , 103.71 , 447.87)	(0.66 , 103.71 , 442.43)	(0.66 , 103.71 , 444.73)	(0.66 , 103.71 , 446.21)	(0.66 , 103.71 , 438.87)
Commuter Rail IVT (mean)	63.62	55.98	57.89	57.29	60.07
(min,max,sd)	(2.44 , 215.22 , 738.26)	(2.39 , 223.07 , 836.79)	(2.44 , 212.22 , 812.56)	(2.39 , 209.57 , 894.38)	(2.44 , 216.82 , 790.44)
Best Mode (mean)	3.41	3.40	3.38	3.41	3.38
(min,max,sd)	(1.00 , 5.00 , 1.70)	(1.00 , 5.00 , 1.77)	(1.00 , 5.00 , 1.79)	(1.00 , 5.00 , 1.79)	(1.00 , 5.00 , 1.79)
% of Paths using Local Bus	27.96	50.39	44.43	49.19	42.42
% of Paths using Express Bus	8.37	14.35	10.41	13.46	11.88
% of Paths using Light Rail/Ferry	2.50	4.69	4.21	4.58	3.56
% of Paths using Heavy Rail	15.52	26.54	24.65	25.84	22.32
% of Paths using Commuter Rail	4.20	8.24	6.30	8.16	6.75

We also plotted the set of accessible TAPs from some key locations to ensure transit network connectivity as well as appropriateness of the path building parameters being used in transit skimming. Specifically, we looked at the TAPs near the TransBay Terminal, Central San Jose and Berkeley. For this analysis the AM and PM peak period skim sets were used as most services operate during these hours and hence would present a better picture of the TAP connectivity. The maps show the TAPs that are color coded by whether or not they are accessible. An accessible TAP would show up as green while an inaccessible TAP will show up as red. The origin TAP is shown as a big blue dot. Before analyzing these maps it should be remembered that TAPs are feeders to stops – so a person has to board at least one route that is servicing the TAP first. This behavior might make certain TAP pairs inaccessible because the resultant routes would end up exceeding the maximum number of transfers (set at 3) or the maximum generalized cost (10 hours). For instance, TAP 603 is the TransBay terminal TAP – we can see from the map that some sections of San Jose and Gilroy are not accessible (even though there are services between the two locations whose run times/transfers are well within the limits). This is because all services at TAP 603 crosses the Bay Bridge and this results in a roundabout path to reach Gilroy/San Jose. While a TAP that is very close to the TransBay terminal TAP – TAP 487 – can access more TAPs in San Jose and Gilroy. While planning a trip from San Francisco to Gilroy, the TAP selection model within CT-RAMP will ensure that the correct set of TAPs is exposed in the choice set. Keeping this caveat in mind, we can see that the TAP coverage is extensive from the different locations.

Figure 13: TAPs accessible from Trans Bay Terminal [603] in AM Period

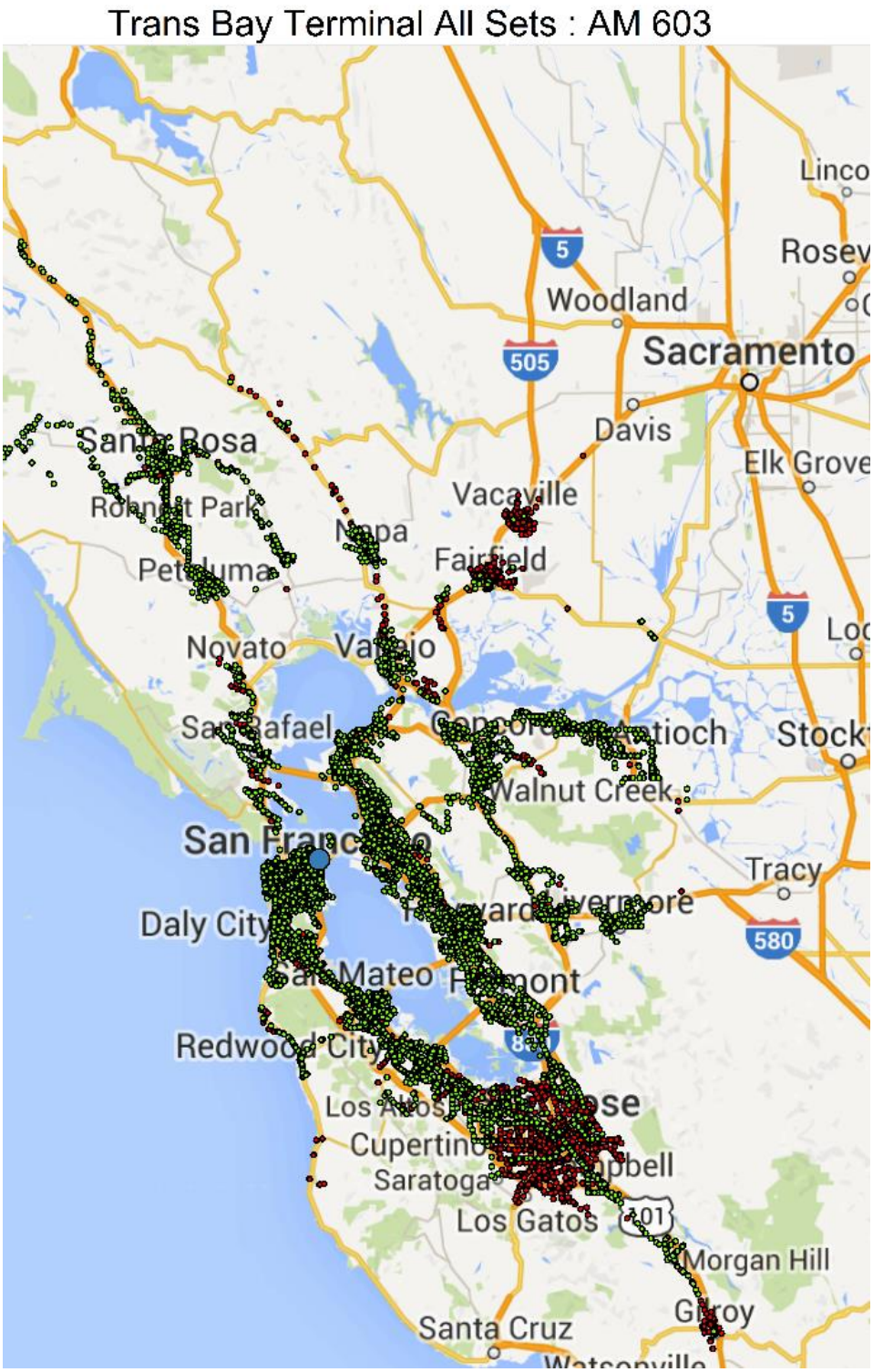


Figure 14: TAPs accessible from a Local TAP close to Trans Bay Terminal [487] in AM Period

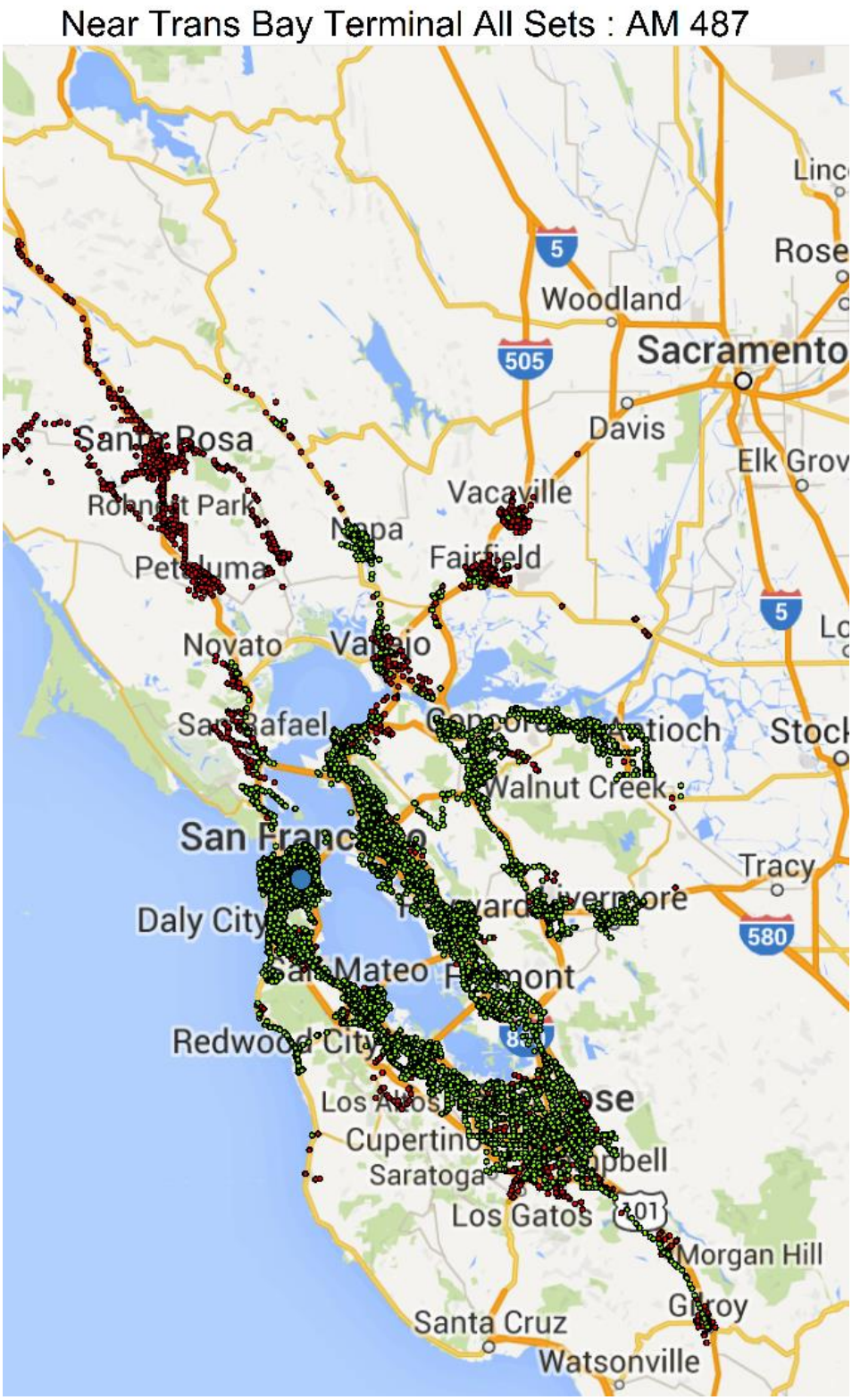


Figure 15: TAPs accessible from Berkeley [4117] in PM Period

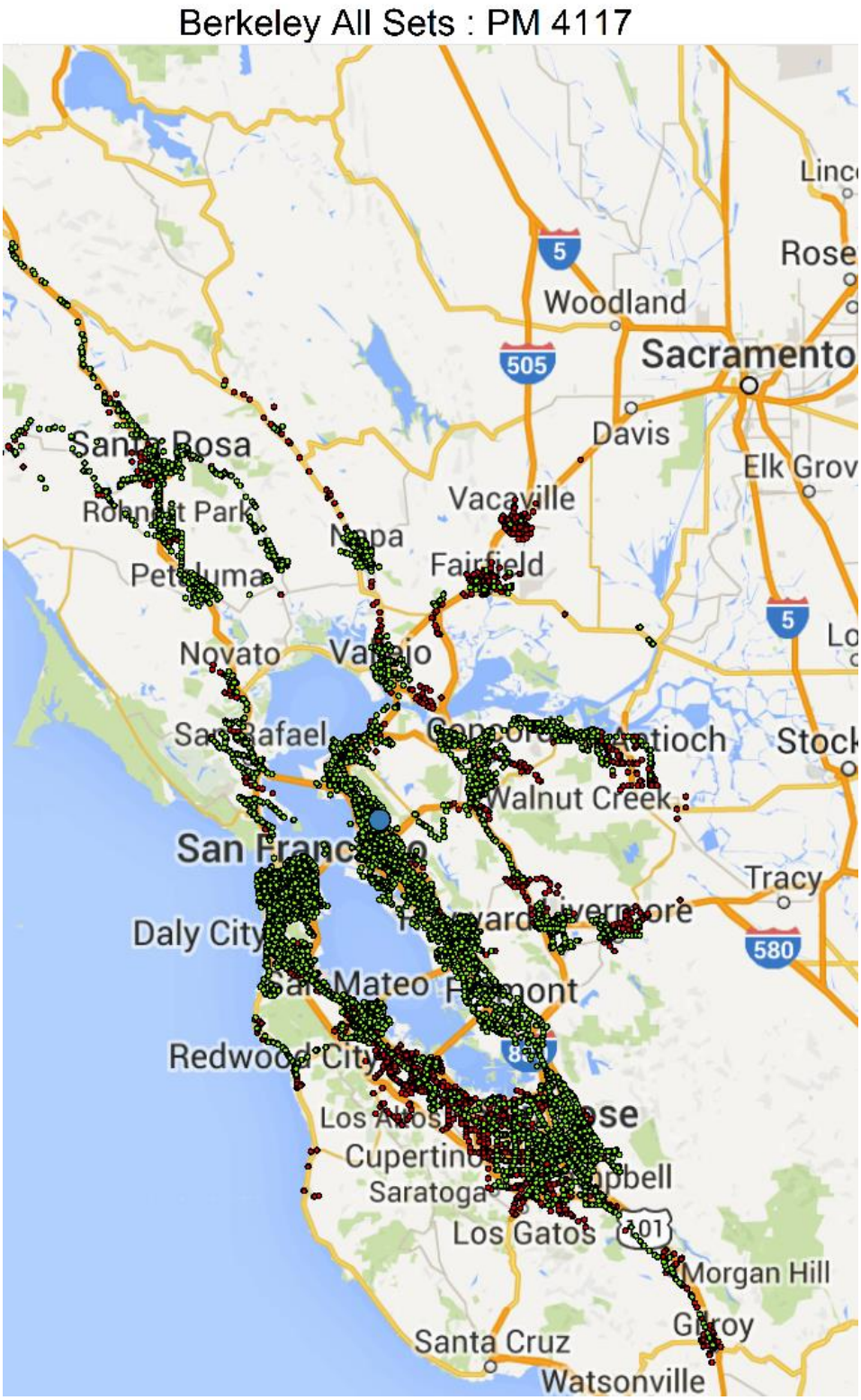
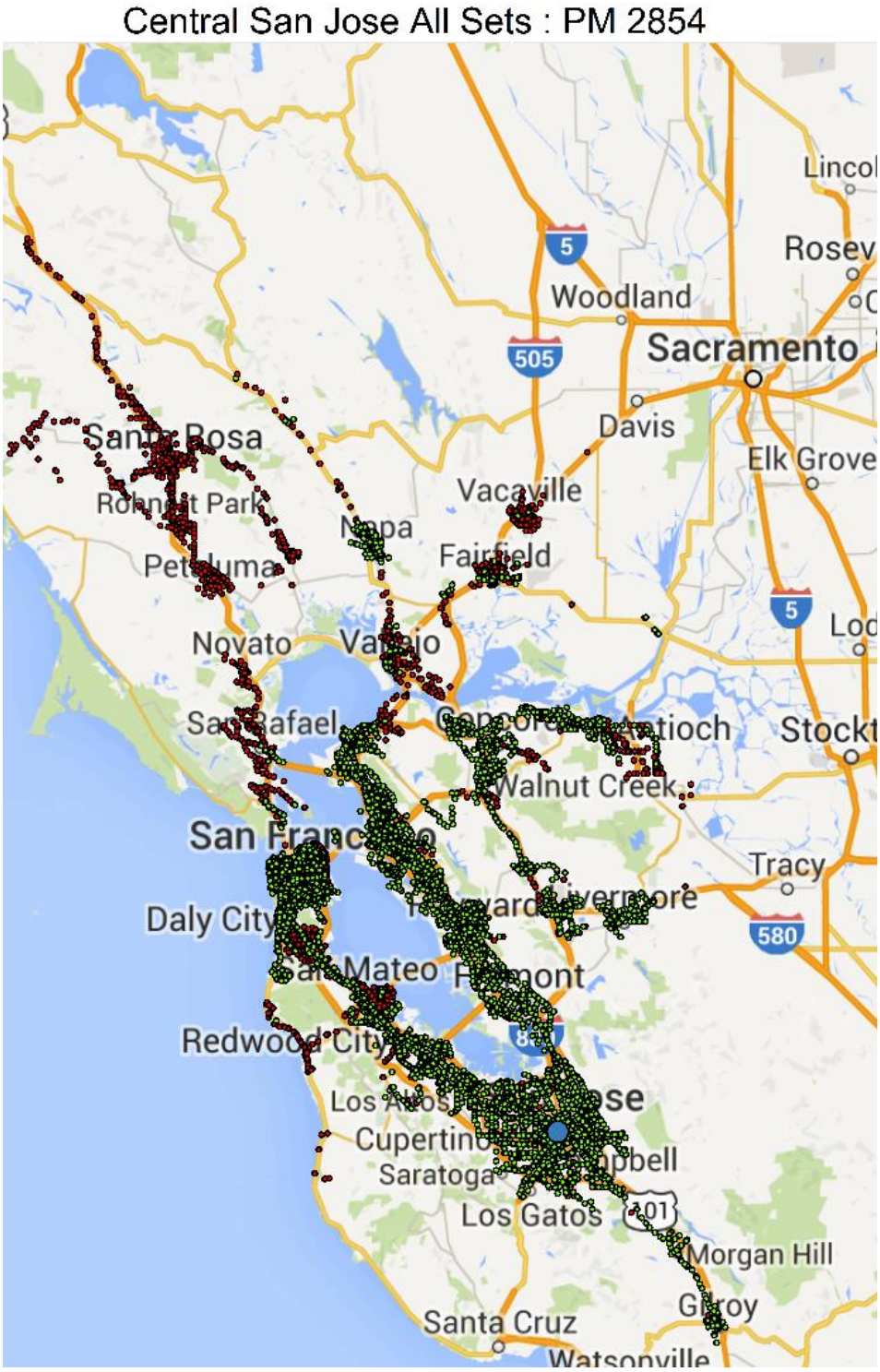


Figure 16: TAPs accessible from Central San Jose [2845] in PM Period



As a further verification of the transit skims, transit trips that are generated from CT-RAMP were selected and mapped. These were compared with the Google Transit Trip planner to see if the paths generated were reasonable. In following pages the map of the trip from the model is presented first followed by that generated by Google. The model just outputs origin and destination MAZ and boarding and alighting TAPs – the path has been approximated as a straight lines. We also compare the walk and travel times generated by the skims and Google.

Figure 17a: Berkeley to San Francisco [MODEL]

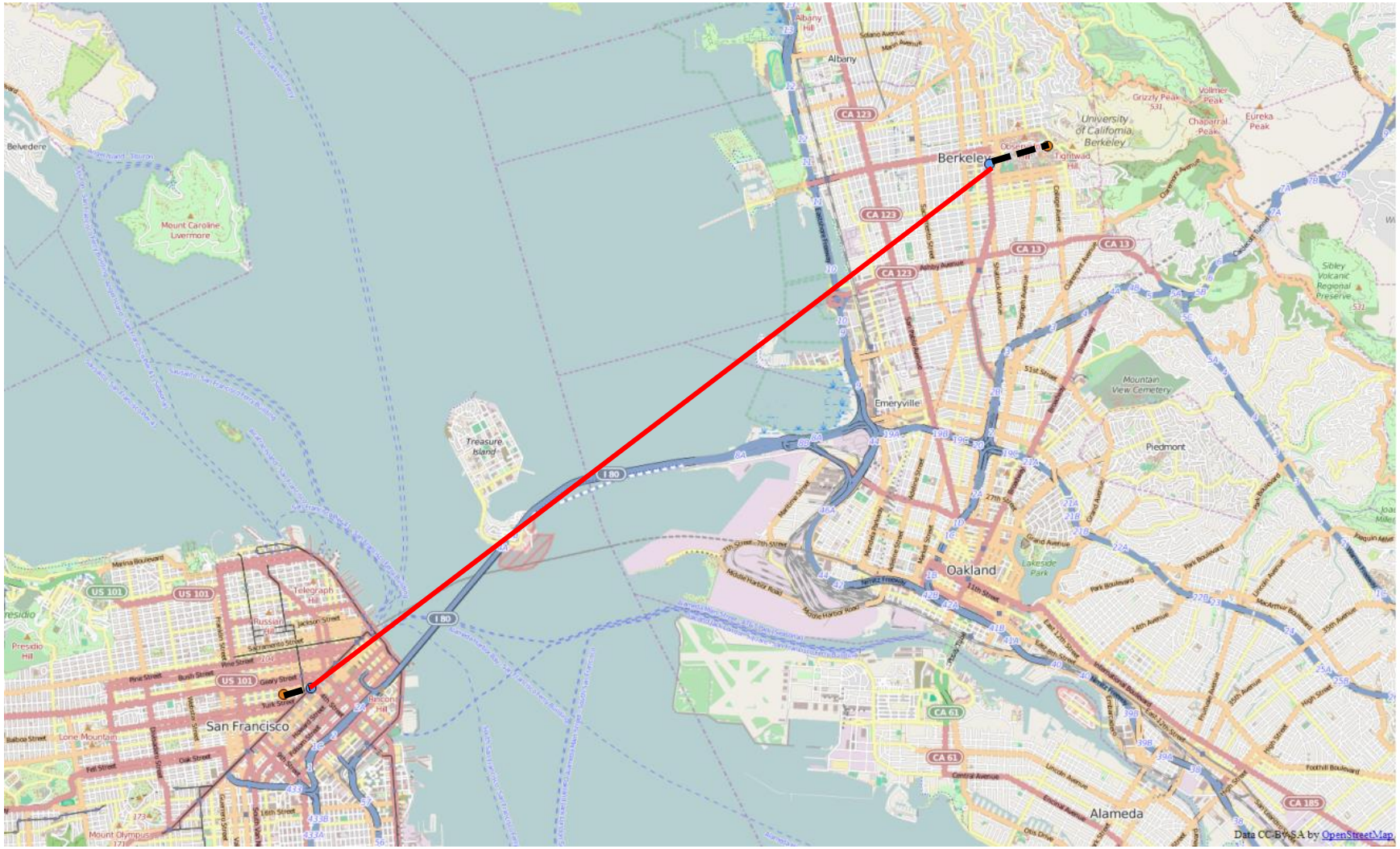
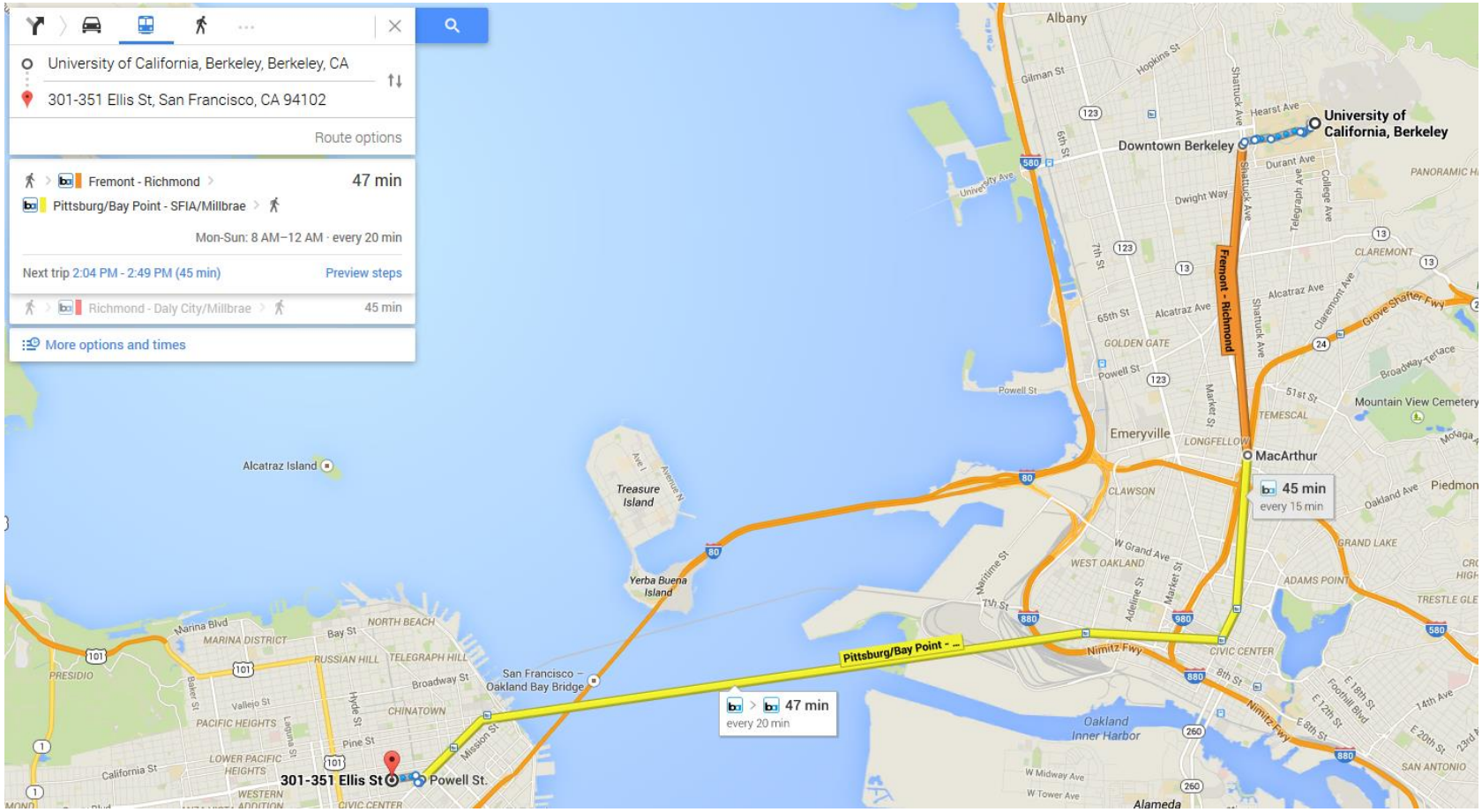


Figure 17b: Berkeley to San Francisco [GOOGLE]



	Google	Model
Access	14	10
IVT	33	39
Egress	6	4
Total	**53**	**53.6**
Transfers	**1**	**0**

Figure 18a: San Francisco Financial District to San Francisco Diamond Heights [MODEL]

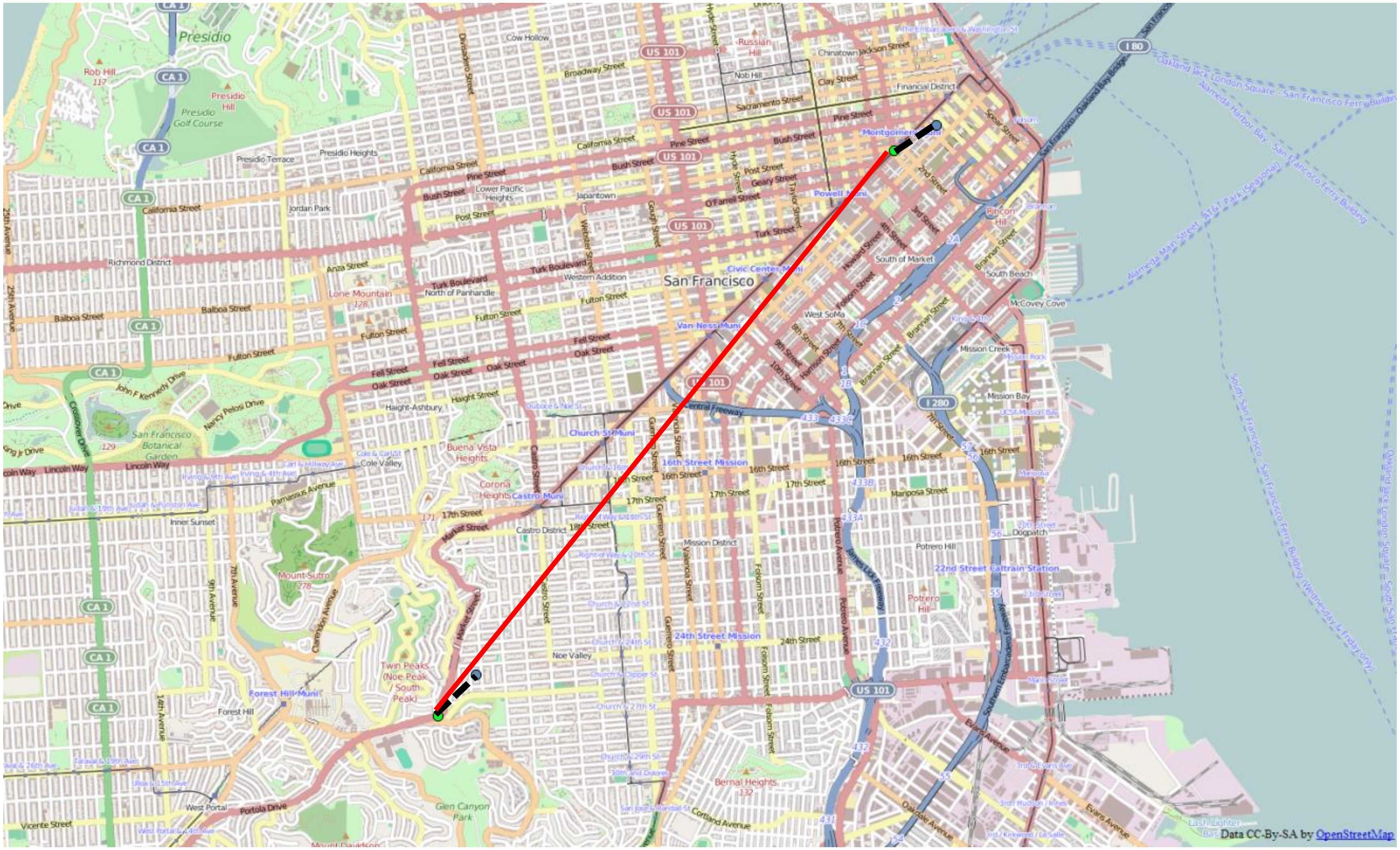
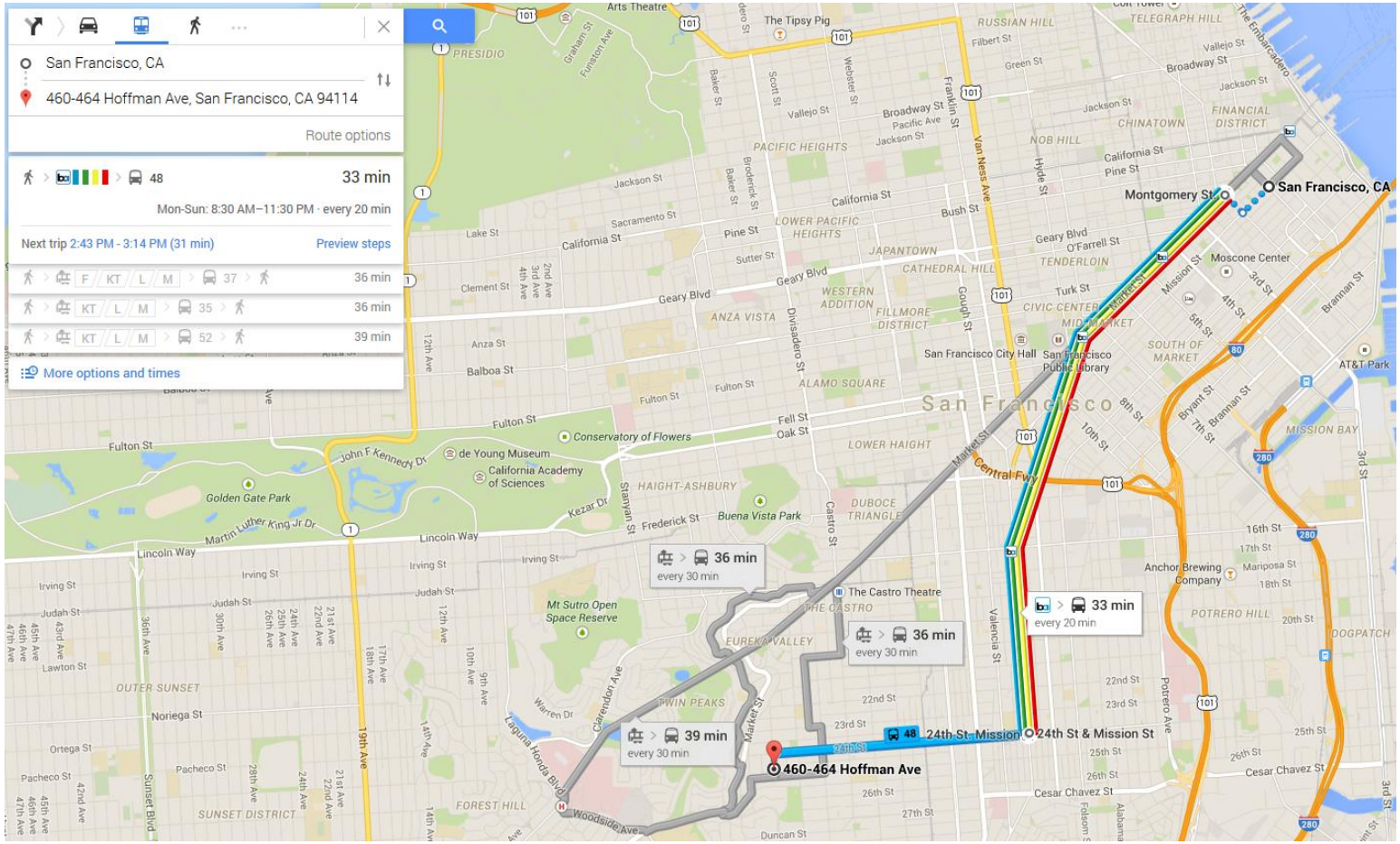


Figure 18b: San Francisco Financial District to San Francisco Diamond Heights [GOOGLE]



	Google	Model
Access	6	4
IVT	18	32
Egress	3	4
Total	**27**	**39**
Transfers	**1**	**1**

Figure 19a: San Francisco to Richmond [MODEL]

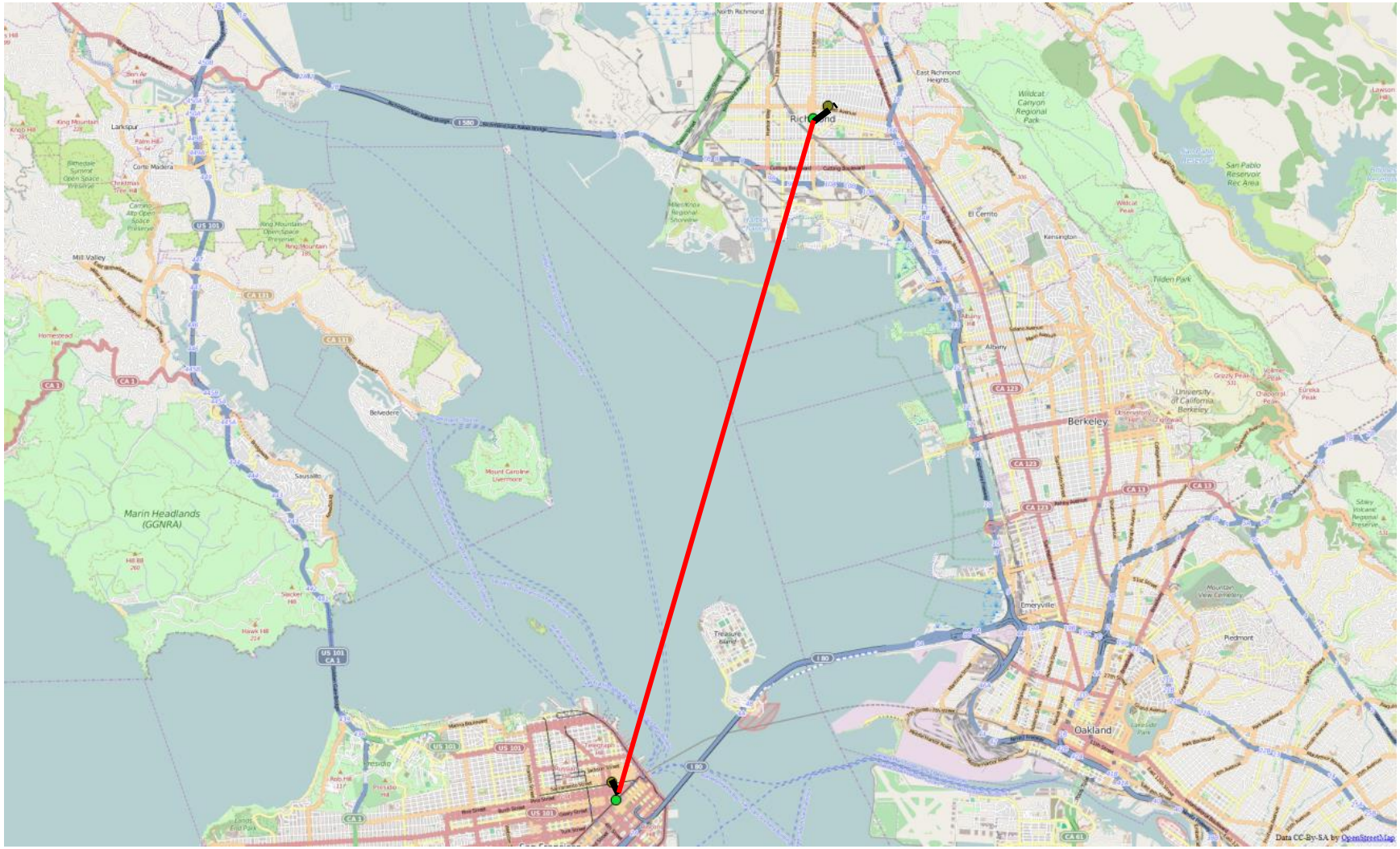
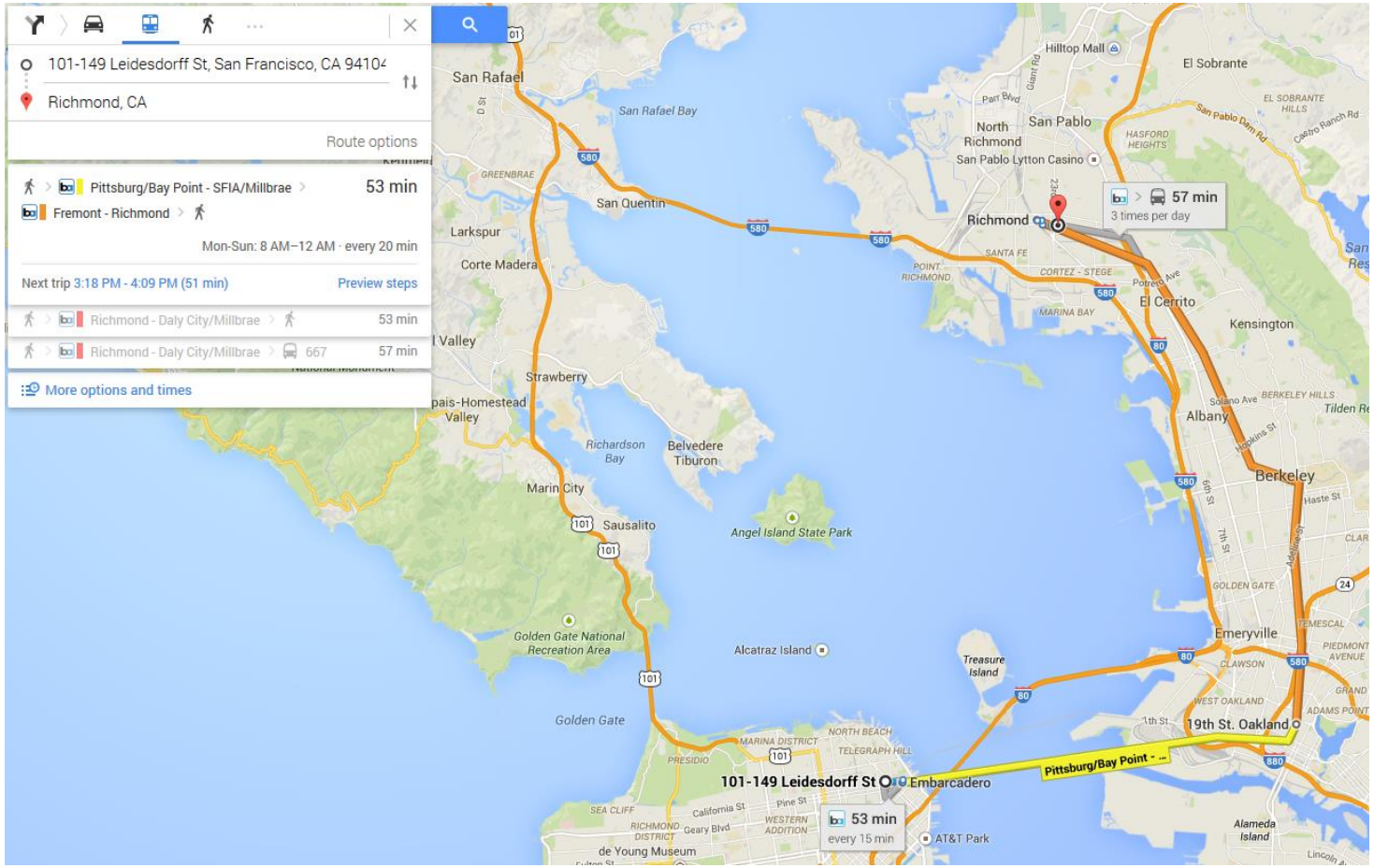


Figure 19b: San Francisco to Richmond [GOOGLE]



	Google	Model
Access	9	6
IVT	35	64
Egress	8	6
Total	**52**	**75**
Transfers	**1**	**1**

Figure 20a: An example short transit trip produced by the model [MODEL]

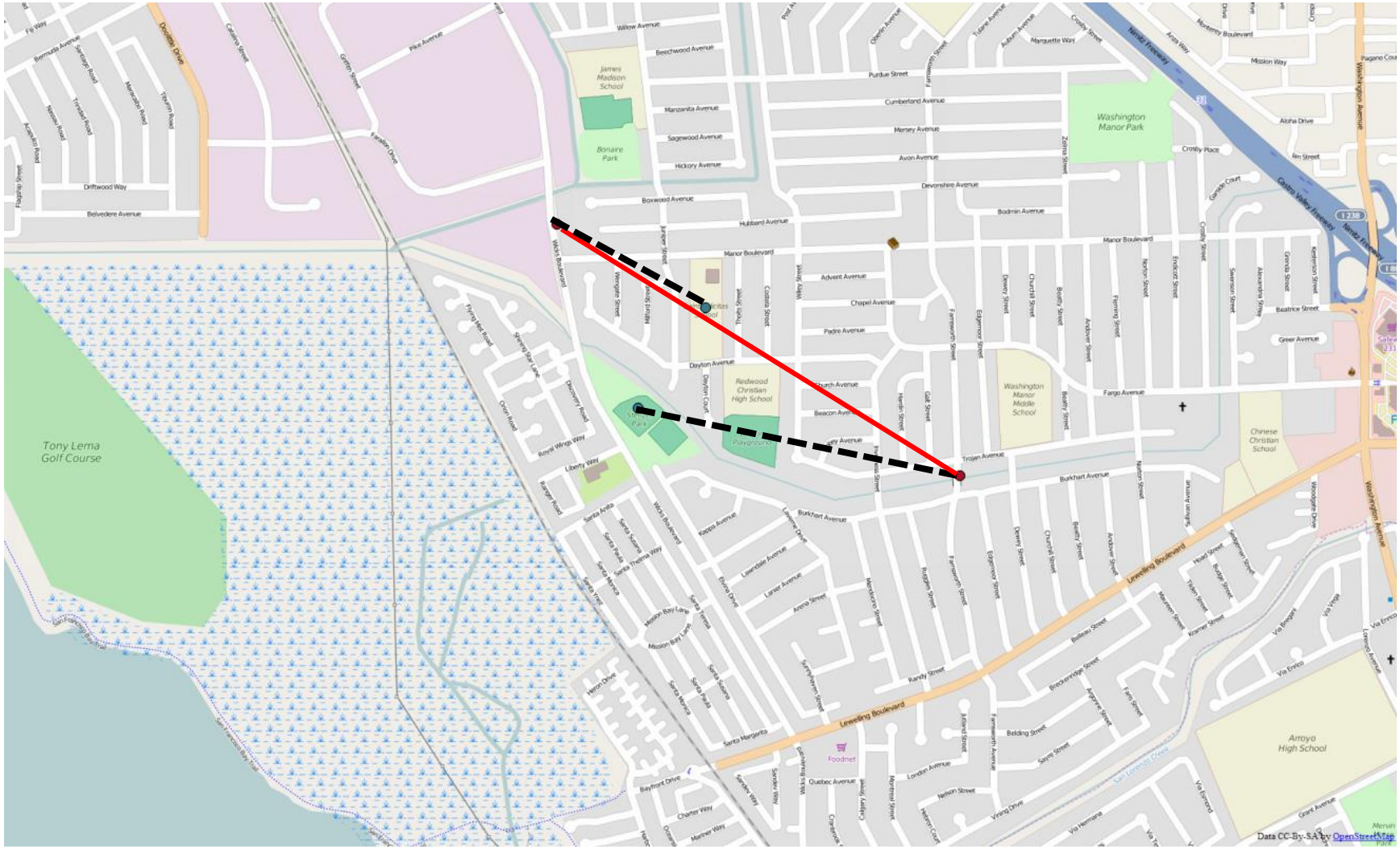
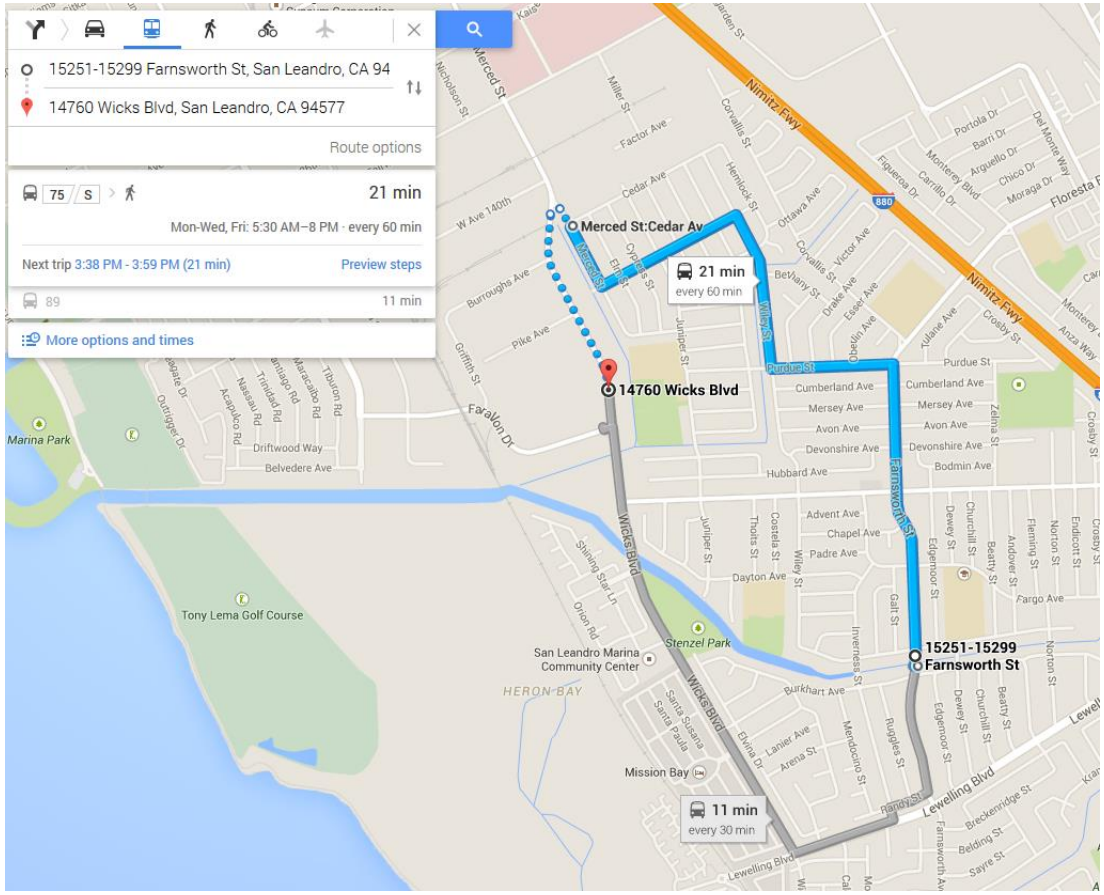


Figure 20b: An example short transit trip produced by the model [GOOGLE]



	Google	Model
Access	0	0
IVT	12	23
Egress	9	3
Total	**21**	**26**
Transfers	**0**	**0**

From the maps above we can see that the routes being predicted by the model are similar to what is being generated on Google. In the first case we see that the times match very closely (Berkeley to San Francisco example). For the second and third example that we have shown the model data is a bit higher. The final example shows a short trip that is 0.02 miles apart and it is using transit – this does not seem like a logical choice as walk is much better in this case, but it is likely that mode choice parameters are off resulting in transit getting a higher utility. In any case the model and Google predicts similar routes – this suggests that the transit component process is working correctly. Of course different wait curves will result in different routes as well, and this is an area of improvement for the next phase of work. It should also be noted that the trips shown here are synthetic in nature, and that is would be better to assign the on-board survey data with the *Travel Model Two* software to illustrate goodness-of-fit.

7 CT-RAMP

CT-RAMP models the travel behavior of the individuals (households and person) living in the model region. This includes determining the number of vehicles per household; the household daily activity patterns; the workplace and school location; the tour frequency, destination, and time-of-day choice; and mode choice. Basic tour, trip, and mode-choice results are presented to illustrate that the model is producing reasonable results.

The summaries in this section are based on a 33% sample run expanded to 100%. The following table summarizes the number of tours and trips per household and person. The percentage of households making tours (~ 95%), persons making tours (~90%), and households making joint tours (~15%) are sensible. Also reasonable are the average tours and trips per household and person.

Table 25 : Tour and Trip Summaries for Individual and Joint Tours

	INDIVIDUAL	JOINT
HH	2,596,982	2,596,982
% HH with 0 Tours	5.20	83.21
Average Tours/HH (excluding zero-tour HHs)	3.46	1.24
Average Trips/HH (excluding zero-trip HHs)	8.76	3.00
Average Trips/Tour	2.53	2.43
Total Persons	6,756,527	NaN
% Persons with 0 Tours	10.83	NaN
Average Tours/Person (excluding zero-tour persons)	1.41	NaN
Average Trips/Person (excluding zero-trip persons)	3.58	NaN

The following tables show tour and trip counts by mode and tour type, for individual and joint tours. The first table below shows individual tours by mode and tour type. The mode splits are reasonable, with ~40% drive alone, 75% auto, 11% non-motorized, and 14% transit. The tour splits are also realistic, with 34% of tours being mandatory work tours. We also note that paths from all sets of transit skims are being used in tour mode choice. Please note that at this stage we have not performed validation of the HOT choice mechanics.

The next table presents individual trips by mode and tour type. The tour type splits are roughly the same as with the individual tour summaries, and thus are sensible. The mode splits are also, as expected, similar to those of the individual tour summary. The increase in drive alone share to 50% is due to the individual legs of a tour tending to use drive alone in spite of the tour mode (for example a drive-to-transit tour may include drive alone trip legs at the beginning and end to access tour stops). Similar to tour mode choice we see paths from all sets appear in trip mode choice.

The next two tables present the joint tours and trips by mode and tour type. The tour and trip results are roughly equivalent (as expected). The tour splits are reasonable, with the joint tours only including maintenance and discretionary tour types as mandatory joint tours are not modelled in CT-RAMP. The split amongst the tour types shows no anomalous or worrisome distribution. The mode splits for the joint tours are also sensible, with just under 80% using drive modes, about 20% using non-motorized, and less than

2% selecting transit modes. The fact that there are no park-n-ride modes selected seems worrisome, but the mode choice coefficients for park-n-ride are severely negative and thus these results are not unexpected (the kiss-n-ride coefficients are also very negative, but there are some positive adjustment coefficients in relation to the park-n-ride modes; hence the small – but non-zero – kiss-n-ride mode share is sensible). Also, as noted earlier, this is based on a 33% sample which might not be able to capture all combinations of trips in the transit market as well as un-calibrated constants. The mode choice model will need to be calibrated fully to reflect the changes in accessibility due to the updated representation of supply before drawing conclusions from these summaries.

Table 26 : Individual tours by tour mode and tour purpose

Mode	Work	University	School	Escort	Shop	Maintenance	Eating Out	Visiting	Discretionary	Work-Based	All	Total Percent
Drive Alone Free	1,636,076	73,794	23,452	216,021	421,945	376,615	57,576	81,548	230,218	113,148	3,230,394	38.0%
Drive Alone Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 2 GP	303,042	19,476	158,515	183,467	164,476	128,400	25,106	59,803	133,024	35,488	1,210,797	14.2%
Shared Ride 2 HOV	192,861	7,412	5,582	13,830	15,379	28,982	2,327	12,930	12,924	1,576	293,803	3.5%
Shared Ride 2 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 3 GP	122,027	15,727	518,448	135,473	71,827	54,724	16,739	48,712	94,173	23,739	1,101,591	12.9%
Shared Ride 3 HOV	78,758	7,176	20,061	8,903	6,500	11,394	1,548	11,691	10,206	1,312	157,548	1.9%
Shared Ride 3 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Walk	7,564	6,427	134,955	51,755	100,182	104,030	40,115	97,530	272,061	34,609	849,227	10.0%
Bike	1,467	200	16,248	2,730	8,370	6,333	8,218	19,173	51,345	912	114,997	1.4%
Walk Set 1	362,467	46,945	79,042	1,079	125,682	99,988	4,942	13,206	33,112	119,879	886,342	10.4%
Walk Set 2	53,797	5,124	1,667	64	6,406	5,545	215	588	1,133	7,618	82,158	1.0%
Walk Set 3	12	0	0	0	3	0	0	0	0	0	15	0.0%
PNR Set 1	41,585	19,024	5,752	6	306	191	791	5,661	6,112	0	79,427	0.9%
PNR Set 2	32,130	15,773	536	9	748	633	830	19,936	8,009	0	78,606	0.9%
PNR Set 3	0	21	0	0	0	0	0	36	18	0	76	0.0%
KNR Set 1	32,827	28,967	927	70	14,694	11,855	36	273	327	0	89,976	1.1%
KNR Set 2	28,555	25,473	91	67	6,179	6,864	15	373	167	0	67,782	0.8%
KNR Set 3	0	52	0	0	0	0	0	0	0	0	52	0.0%
School Bus	0	0	269,073	0	0	0	0	0	0	0	269,073	3.2%
All	2,893,167	271,591	1,234,348	613,473	942,697	835,555	158,461	371,461	852,830	338,282	8,511,864	100.0%
Total Percent	34.0%	3.2%	14.5%	7.2%	11.1%	9.8%	1.9%	4.4%	10.0%	4.0%	100.0%	

Table 27 : Individual trips by trip mode and tour purpose

Mode	Work	University	School	Escort	Shop	Maintenance	Eating Out	Visiting	Discretionary	Work-Based	All	Total Percent
Drive Alone Free	5,660,464	213,009	59,873	875,261	1,614,058	1,177,661	170,333	249,845	576,191	271,555	10,868,249	50.4%
Drive Alone Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 2 GP	728,470	68,264	513,858	287,445	264,342	207,142	57,412	162,655	304,794	75,982	2,670,364	12.4%
Shared Ride 2 HOV	110,109	6,858	22,655	7,139	8,300	13,127	1,539	9,603	9,964	2,488	191,782	0.9%
Shared Ride 2 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 3 GP	169,967	36,600	1,055,361	176,861	84,445	67,842	26,227	93,579	168,530	42,752	1,922,164	8.9%
Shared Ride 3 HOV	27,873	4,136	49,282	4,276	2,664	4,061	785	6,133	6,142	1,342	106,694	0.5%
Shared Ride 3 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Walk	42,609	27,658	459,488	110,658	258,433	232,724	110,679	218,070	594,976	80,452	2,135,745	9.9%
Bike	3,267	461	33,603	5,755	21,161	14,061	22,342	40,094	110,585	2,082	253,409	1.2%
Walk Set 1	867,521	116,876	163,848	2,252	294,261	216,103	11,285	26,215	64,348	256,130	2,018,839	9.4%
Walk Set 2	166,685	17,885	8,600	203	25,491	20,867	997	2,355	4,839	26,403	274,324	1.3%
Walk Set 3	297	27	6	0	33	15	0	3	0	27	409	0.0%
PNR Set 1	50,097	25,745	8,939	9	309	203	773	5,882	8,576	0	100,533	0.5%
PNR Set 2	88,285	35,852	2,176	15	1,273	1,191	1,145	31,785	15,336	0	177,058	0.8%
PNR Set 3	930	785	3	0	33	67	27	1,597	661	0	4,103	0.0%
KNR Set 1	40,661	38,652	1,597	88	20,261	16,306	30	312	470	0	118,376	0.5%
KNR Set 2	79,245	57,764	376	167	17,606	19,421	36	909	452	0	175,976	0.8%
KNR Set 3	800	1,267	0	3	76	106	0	15	6	0	2,273	0.0%
School Bus	0	0	538,145	0	0	0	0	0	0	0	538,145	2.5%
All	8,037,279	651,836	2,917,809	1,470,130	2,612,745	1,990,897	403,612	849,052	1,865,870	759,212	21,558,442	100.0%
Total Percent	37.3%	3.0%	13.5%	6.8%	12.1%	9.2%	1.9%	3.9%	8.7%	3.5%	100.0%	

Table 28 : Joint tours by tour mode and tour purpose

Mode	Work	University	School	Escort	Shop	Maintenance	Eating Out	Visiting	Discretionary	Work-Based	All	Total Percent
Drive Alone Free	0	0	0	0	0	0	0	0	0	0	0	0.0%
Drive Alone Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 2 GP	0	0	0	0	81,470	74,139	20,976	11,230	27,312	0	215,127	39.9%
Shared Ride 2 HOV	0	0	0	0	3,845	9,500	1,388	1,612	1,973	0	18,318	3.4%
Shared Ride 2 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 3 GP	0	0	0	0	40,297	51,794	20,300	14,200	35,088	0	161,679	30.0%
Shared Ride 3 HOV	0	0	0	0	2,618	8,394	1,627	2,706	2,797	0	18,142	3.4%
Shared Ride 3 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Walk	0	0	0	0	8,348	11,706	25,642	14,079	42,455	0	102,230	19.0%
Bike	0	0	0	0	555	482	312	127	467	0	1,942	0.4%
Walk Set 1	0	0	0	0	7,112	7,985	542	306	967	0	16,912	3.1%
Walk Set 2	0	0	0	0	421	539	36	52	42	0	1,091	0.2%
Walk Set 3	0	0	0	0	0	0	0	0	0	0	0	0.0%
PNR Set 1	0	0	0	0	0	0	0	0	0	0	0	0.0%
PNR Set 2	0	0	0	0	0	0	0	0	0	0	0	0.0%
PNR Set 3	0	0	0	0	0	0	0	0	0	0	0	0.0%
KNR Set 1	0	0	0	0	906	1,206	0	0	0	0	2,112	0.4%
KNR Set 2	0	0	0	0	485	821	0	3	3	0	1,312	0.2%
KNR Set 3	0	0	0	0	0	0	0	0	0	0	0	0.0%
School Bus	0	0	0	0	0	0	0	0	0	0	0	0.0%
All	0	0	0	0	146,058	166,567	70,824	44,315	111,103	0	538,867	100.0%
Total Percent	0.0%	0.0%	0.0%	0.0%	27.1%	30.9%	13.1%	8.2%	20.6%	0.0%	100.0%	

Table 29 : Joint trips by trip mode and tour purpose

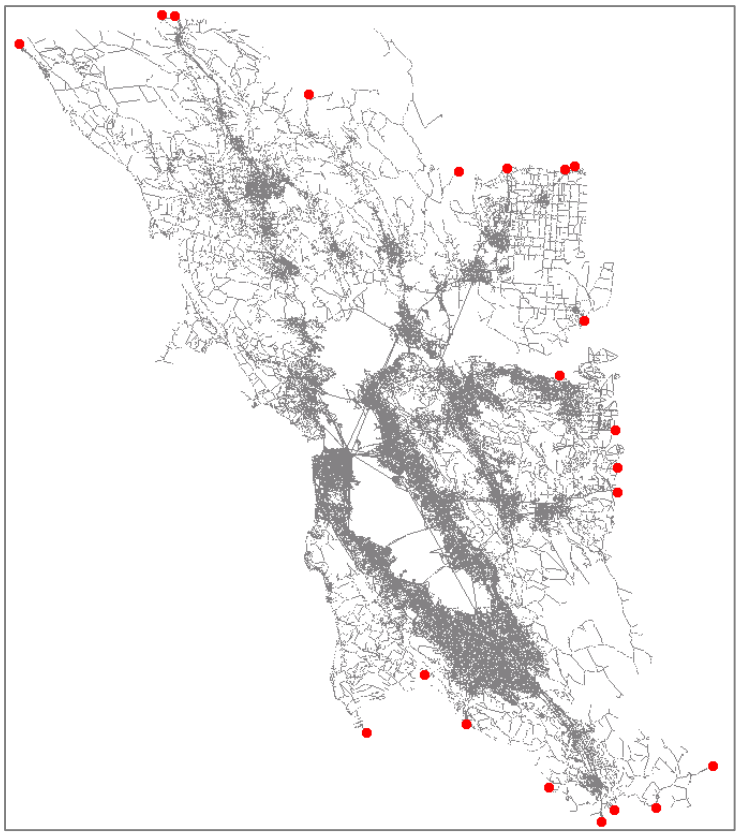
Mode	Work	University	School	Escort	Shop	Maintenance	Eating Out	Visiting	Discretionary	Work-Based	All	Total Percent
Drive Alone Free	0	0	0	0	0	0	0	0	0	0	0	0.0%
Drive Alone Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 2 GP	0	0	0	0	264,797	217,136	57,958	39,912	67,182	0	646,985	49.4%
Shared Ride 2 HOV	0	0	0	0	5,652	9,133	1,491	1,894	2,073	0	20,242	1.5%
Shared Ride 2 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Shared Ride 3 GP	0	0	0	0	98,642	112,288	38,888	28,861	69,500	0	348,179	26.6%
Shared Ride 3 HOV	0	0	0	0	2,945	6,173	1,242	1,800	2,345	0	14,506	1.1%
Shared Ride 3 Pay	0	0	0	0	0	0	0	0	0	0	0	0.0%
Walk	0	0	0	0	21,227	25,745	60,852	30,467	88,679	0	226,970	17.3%
Bike	0	0	0	0	1,379	1,094	745	273	948	0	4,439	0.3%
Walk Set 1	0	0	0	0	16,545	16,927	1,255	685	1,861	0	37,273	2.8%
Walk Set 2	0	0	0	0	1,730	1,970	133	109	182	0	4,124	0.3%
Walk Set 3	0	0	0	0	0	6	0	0	0	0	6	0.0%
PNR Set 1	0	0	0	0	0	0	0	0	0	0	0	0.0%
PNR Set 2	0	0	0	0	0	0	0	0	0	0	0	0.0%
PNR Set 3	0	0	0	0	0	0	0	0	0	0	0	0.0%
KNR Set 1	0	0	0	0	1,052	1,548	0	0	3	0	2,603	0.2%
KNR Set 2	0	0	0	0	1,148	2,191	0	6	0	0	3,345	0.3%
KNR Set 3	0	0	0	0	0	12	0	0	3	0	15	0.0%
School Bus	0	0	0	0	0	0	0	0	0	0	0	0.0%
All	0	0	0	0	415,118	394,224	162,564	104,006	232,776	0	1,308,688	100.0%
Total Percent	0.0%	0.0%	0.0%	0.0%	31.7%	30.1%	12.4%	7.9%	17.8%	0.0%	100.0%	

8 Internal-External Trips

8.1 IX Trip Forecast, IX Trip Time-of-Day, IX Toll Choice

The internal-external (IX) trip model uses a 2005 base-year trip table and grows the trips based on growth rates specific to each external zone. The time-of-day split is calculated based on fixed factors and the toll-choice split uses a simple logit model using travel time and cost. A map showing the external stations is presented below.

Figure 21: External Station Locations



The tables below present a summary of the crossing (in and out) by station's county. It is seen that the two counties which are completely "internal" to the region – San Francisco and Marin – have no external trip ends. Also, external-external (XX) trips were recorded for Solano county and are presented in the final table. Overall the results appear reasonable.

Table 30 : Internal-External Trips by County of External Station

Internal County \ *External County*	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma	Total	% of Total
Alameda	46,891	4,252	-	390	-	83	6,172	7,980	851	66,618	22.22%
Contra Costa	10,287	1,568	-	351	-	19	1,111	9,441	517	23,295	7.77%
Marin	345	49	-	289	-	5	157	1,293	827	2,964	0.99%
Napa	437	31	-	771	-	0	192	2,858	384	4,673	1.56%
San Francisco	3,375	286	-	395	-	39	1,814	6,219	893	13,020	4.34%
San Mateo	3,017	269	-	101	-	121	2,607	2,650	776	9,542	3.18%
Santa Clara	15,157	1,404	-	277	-	2,258	84,713	4,184	273	108,265	36.11%
Solano	2,346	267	-	1,132	-	4	662	55,676	113	60,200	20.08%
Sonoma	342	50	-	1,993	-	-	136	2,329	6,422	11,273	3.76%
All	82,196	8,176	-	5,699	-	2,529	97,563	92,631	11,055	299,850	100.00%
% of Total	27.41%	2.73%	0.00%	1.90%	0.00%	0.84%	32.54%	30.89%	3.69%	100.00%	

Table 31 : External-Internal Trips by County of External Station

External County \ *Internal County*	Alameda	Contra Costa	Marin	Napa	San Francisco	San Mateo	Santa Clara	Solano	Sonoma	Total	% of Total
Alameda	46,891	10,288	345	437	3,375	3,017	15,157	2,346	342	82,197	27.41%
Contra Costa	4,252	1,568	49	31	286	269	1,404	267	50	8,176	2.73%
Marin	-	-	-	-	-	-	-	-	-	-	0.00%
Napa	390	351	289	771	395	101	277	1,132	1,993	5,699	1.90%
San Francisco	-	-	-	-	-	-	-	-	-	-	0.00%
San Mateo	83	19	5	0	39	121	2,258	4	-	2,529	0.84%
Santa Clara	6,173	1,112	157	192	1,814	2,607	84,712	661	136	97,564	32.54%
Solano	7,980	9,441	1,294	2,858	6,218	2,650	4,185	55,676	2,329	92,631	30.89%
Sonoma	851	517	827	384	893	776	273	113	6,423	11,055	3.69%
All	66,620	23,295	2,965	4,673	13,020	9,542	108,265	60,199	11,273	299,852	100.00%
% of Total	22.22%	7.77%	0.99%	1.56%	4.34%	3.18%	36.11%	20.08%	3.76%	100.00%	

Table 32 : External-External Trips by County of External Station

	External County										
External County	**Alameda**	**Contra Costa**	**Marin**	**Napa**	**San Francisco**	**San Mateo**	**Santa Clara**	**Solano**	**Sonoma**	**Total**	**% of Total**
Alameda	-	-	-	-	-	-	-	-	-	-	0.00%
Contra Costa	-	-	-	-	-	-	-	-	-	-	0.00%
Marin	-	-	-	-	-	-	-	-	-	-	0.00%
Napa	-	-	-	-	-	-	-	-	-	-	0.00%
San Francisco	-	-	-	-	-	-	-	-	-	-	0.00%
San Mateo	-	-	-	-	-	-	-	-	-	-	0.00%
Santa Clara	-	-	-	-	-	-	-	-	-	-	0.00%
Solano	-	-	-	-	-	-	-	31,602	-	31,602	100.00%
Sonoma	-	-	-	-	-	-	-	-	-	-	0.00%
All	-	-	-	-	-	-	-	31,602	-	31,602	100.00%
% of Total	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%	

9 Truck Trips

9.1 Truck Trip Generation, Distribution, Time-of-Day, and Toll Choice

The truck model is a gravity model with a fixed-factor time-of-day split and a simple logit toll-choice model (using travel time and cost). The truck trip generation program creates productions and attractions via linear regression using a simplified set of zonal data (employment and number of households) that the base MAZ data is aggregated to. Trip distribution uses time as the impedance and fixed friction- and *k*-factors to adjust the results.

The following verification tables present a summary of the productions, attractions, and final trips by truck type (mode). Note there is a number precision (rounding) issue that results in the differences in the totals.

Table 33 : Truck Model Production, Attraction, and Trips by Mode

Truck Type	Productions	Attractions	Trips
Very Small (VSM)	1,107,070	1,107,070	1,090,788
Small (SML)	188,512	188,475	163,682
Medium (MED)	17,569	17,399	14,097
Large (LRG)	40,153	39,911	23,668
Total	1,353,304	1,352,855	1,292,234

The charts below present trip distance and time distributions for truck trips. The distributions not only have reasonable distributions, but it is also seen that the larger truck trips skew towards longer trips, which is expected as longer haul trips tend to use larger trucks.

Figure 22: Truck Trip Distance Distribution by Mode

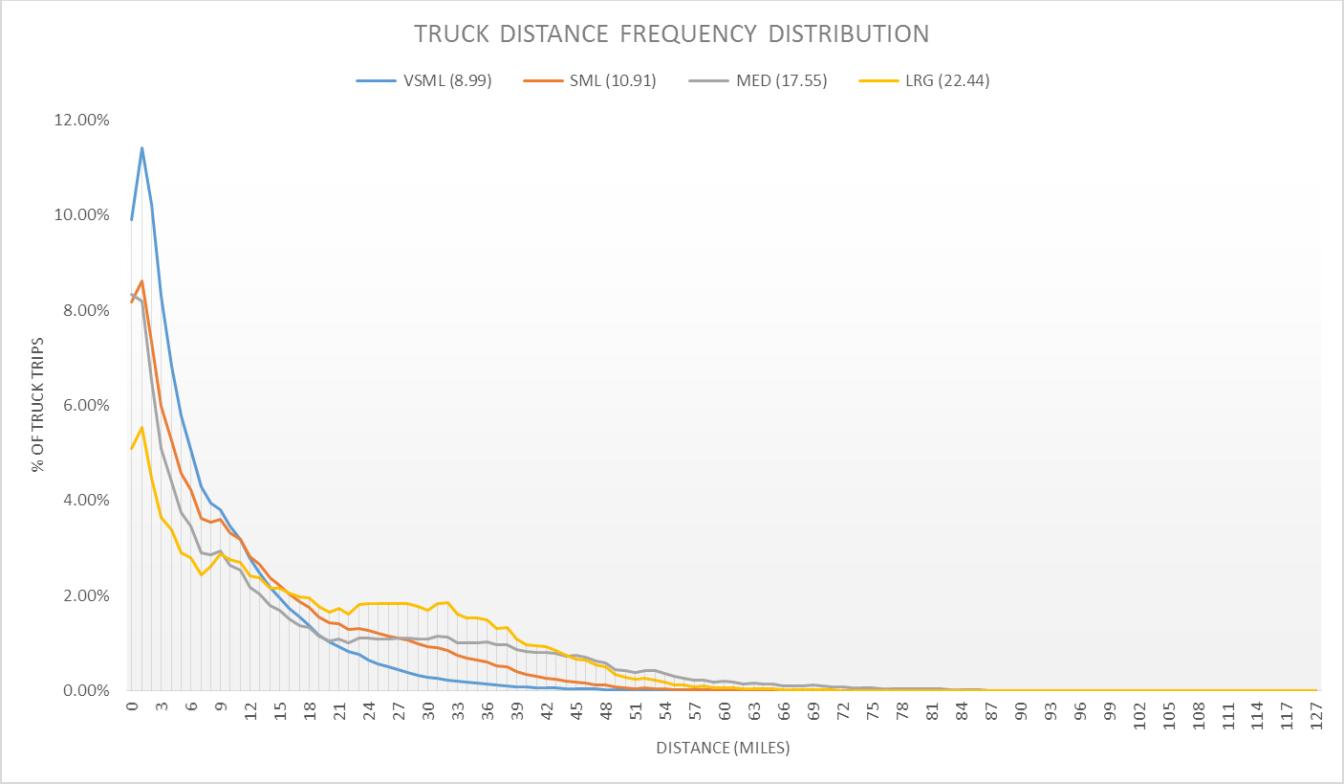
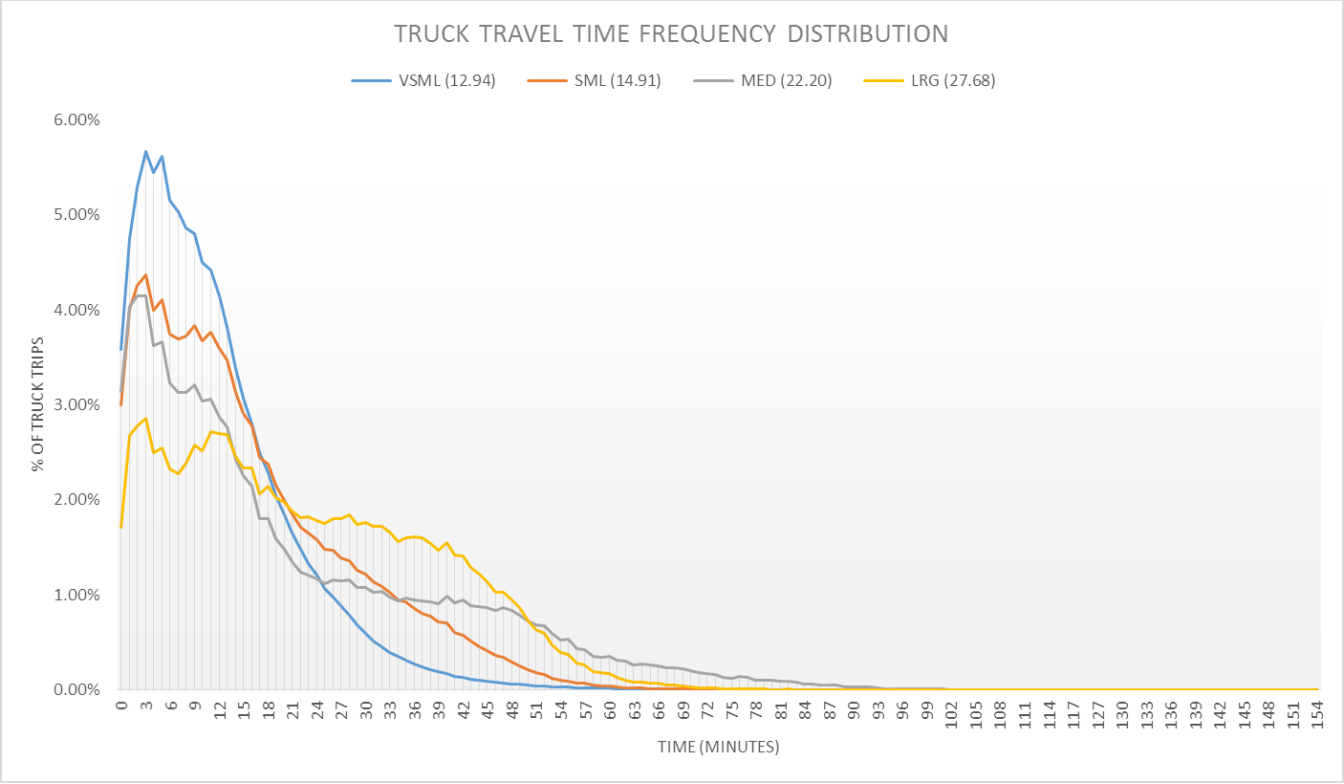


Figure 23: Truck Trip Time Distribution by Mode



10 Highway Assignment

Highway assignment is run using Cube's HIGHWAY procedure at the end of each feedback iteration. A separate assignment is run for each of the five time periods (EA, AM, MD, PM, and EV), and the results are averaged (via a method-of-successive averages (MSA) procedure) with the previous feedback iterations. This averaged result is used to generate travel times which are then used to generate updated skims and new model results for the next feedback iteration.

The first verification check that was performed for the highway assignment was a check on the network usage: essentially verifying that the parts of the network which are not used are not major roads (at least in comparison to those that are), and that the used network facilities provide adequate connectivity to the TAZs. As part of this, a summary of the number of zero-volume links by period and functional type is presented in the following table.

It is shown that the freeway and major links all have high usage (non-zero volume) in the assignment (> 85%), with the lower usage links in the collector, or other "lesser" facility types. Further, within the five broad time periods we can see heightened usage (lesser share of zero volume links) of facilities in the peak periods and during mid-day.

A visual representation of non-zero volume links is presented in the three network maps shown below. These images color the AM peak assignment network (after two feedback iterations) such that the zero-volume links are grey, non-zero-volume links are green, and TAZ connectors are blue. The first map is of the entire region, the next is of the San Francisco peninsula, and the final is a close-up of the Bay Bridge interchange in San Francisco.

It is seen that the major network links (freeways, arterials, *etc.*) are all being used, and that the grey links are intermittent and more representative of the "background" network. Especially evident in the second and third map is that the TAZ connectors all provide good access to the network via the major roadway network and do not force the lesser links to be used unnecessarily. These maps were generated after just three iterations of highway assignment – as we perform more iterations the volumes will be spread across competing links and we would observe even lesser number of unused links.

Table 34 : Zero-Volume Link Count Summary by Facility Type

Facility Type	Zero-Volume Link Count (% of Total)					
	EA	AM	MD	PM	EV	Total
Freeway Connector	65 (8.31%)	43 (6.64%)	52 (8.54%)	52 (7.89%)	103 (15.06%)	315 (9.31%)
Freeway	1,444 (7.68%)	516 (2.89%)	442 (2.69%)	953 (6.10%)	3,295 (16.39%)	6,650 (7.49%)
Expressway	1,320 (5.21%)	679 (3.02%)	510 (2.24%)	611 (2.69%)	2,423 (8.40%)	5,543 (4.54%)
Collector	576,020 (81.07%)	453,640 (63.28%)	383,411 (60.81%)	389,237 (63.32%)	481,717 (75.40%)	2,284,025 (68.97%)
Freeway Ramp	726 (10.45%)	440 (6.69%)	368 (6.19%)	371 (6.49%)	465 (9.90%)	2,370 (7.93%)
Major Arterial	26,516 (13.39%)	8,915 (4.68%)	7,902 (4.68%)	8,387 (5.08%)	20,104 (10.97%)	71,824 (7.93%)
Special Facility	-	-	-	-	37 (100.00%)	37 (100.00%)

Figure 24: AM Highway Assignment Network Usage
(unused links are grey, TAZ connectors are blue, used network links are green)

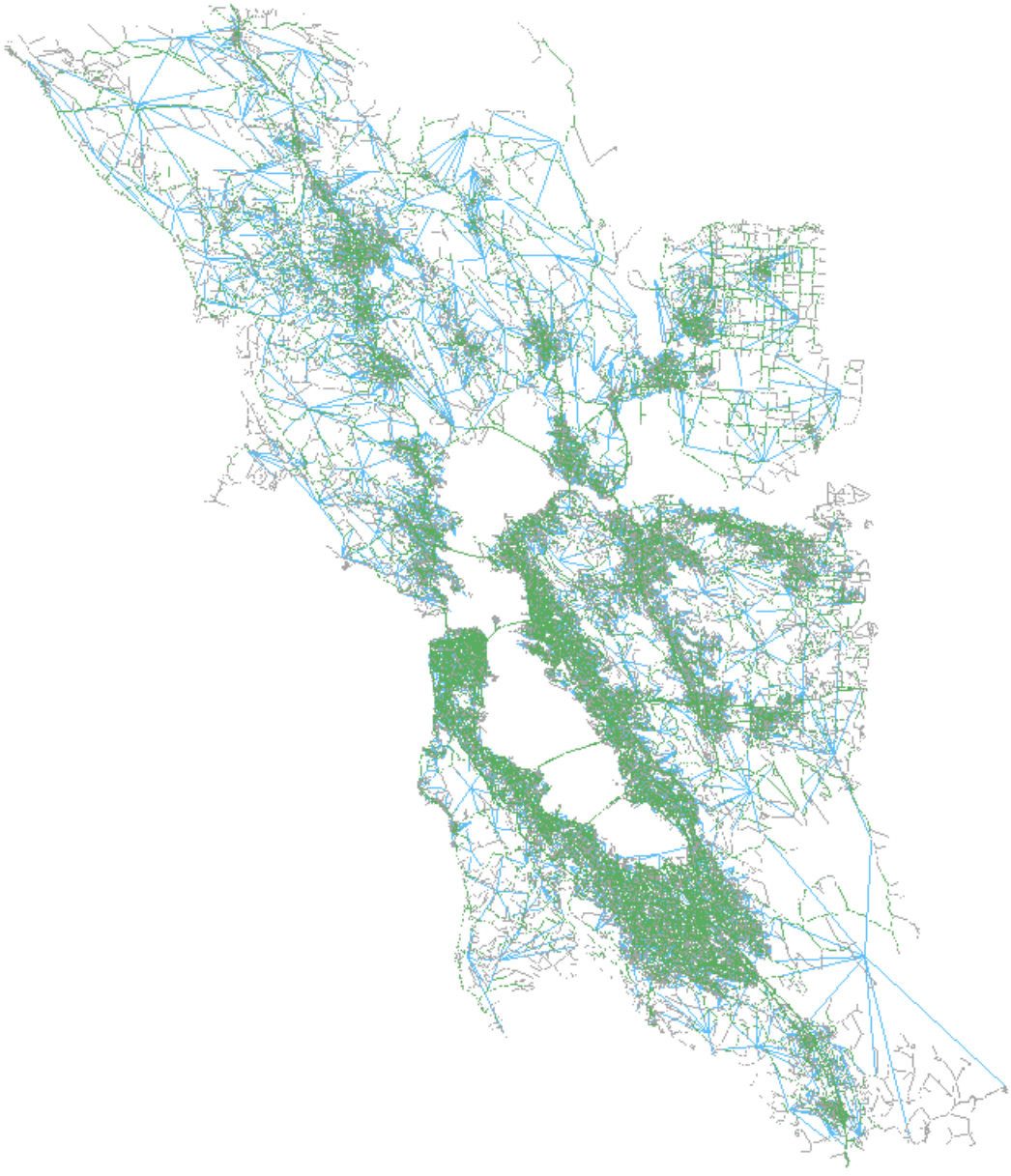


Figure 25: AM Highway Assignment Network Usage for San Francisco Peninsula (unused links are grey, TAZ connectors are blue, used network links are green)

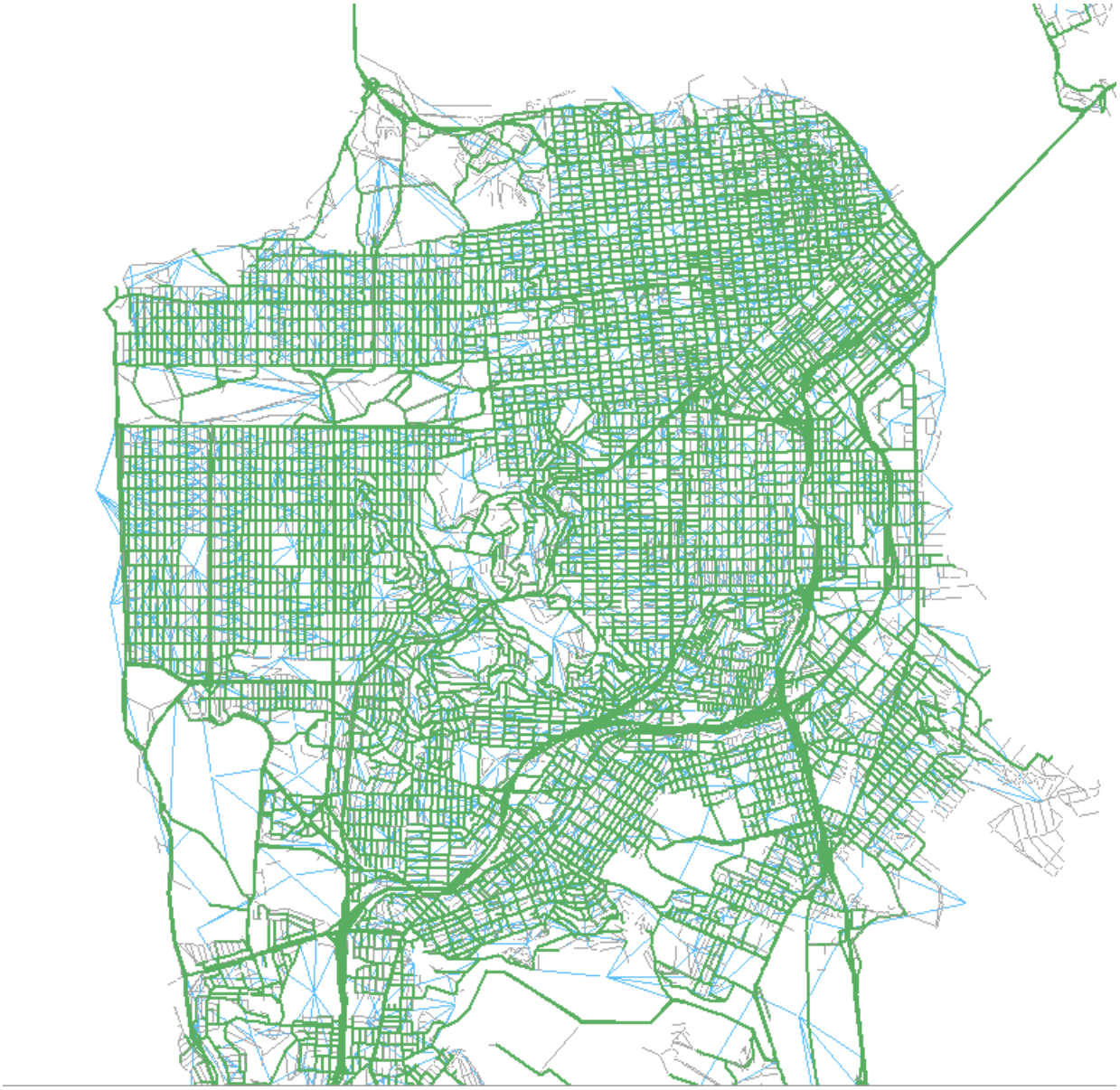
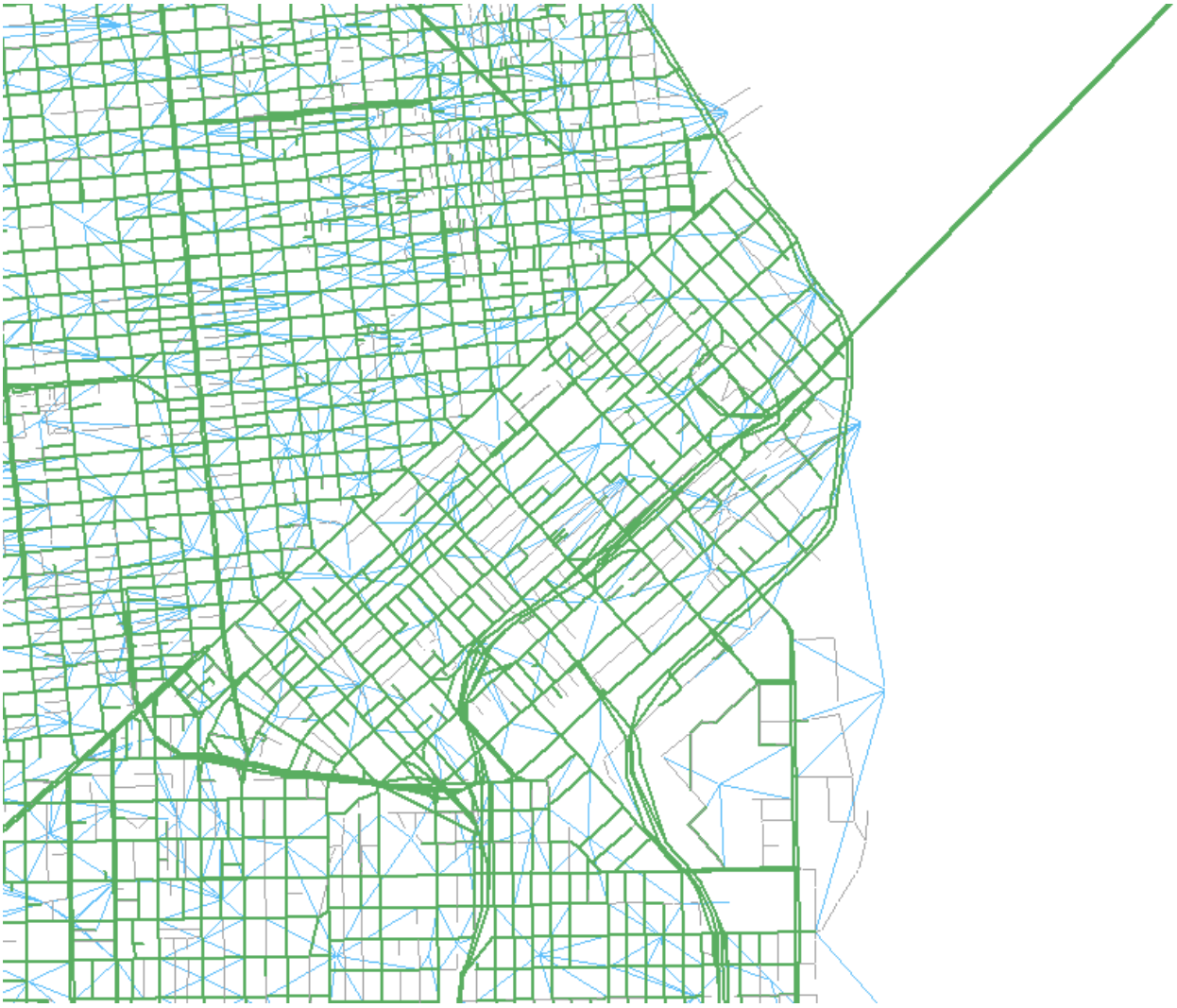


Figure 26: AM Highway Assignment Network Usage for Bay Bridge Interchange in San Francisco (unused links are grey, TAZ connectors are blue, used network links are green)



The assigned volumes were also checked for being reasonable. To facilitate this check, network maps were made with the link color and width set according to its assigned volume. Again, the AM assignment network after two feedback iterations was used. The following figure shows the legend used for the volume groups and link colors/widths used.

Figure 27: Network Volume Map Legend

Volume group	Link color	Link width (pixels)
(0,500]		1
(500,1500]		2
(1500,5000]		3
(5000,10000]		4
(10000,25000]		5
(25000,+Inf)		6

Using these groupings, the following maps were produced and are presented below in order: the Bay Bridge interchange in San Francisco, the Richmond-San Rafael bridge interchange in San Rafael, and the region around the San Jose International.

In each of these maps, it is seen that the major roads, especially the freeways and major arterials, are those getting the larger volumes. Also, the volume transitions between the various links are sensible and do not appear to show unrealistic discontinuities.

Figure 28: AM Peak Highway Assignment Volume Summary for Bay Bridge Interchange in San Francisco

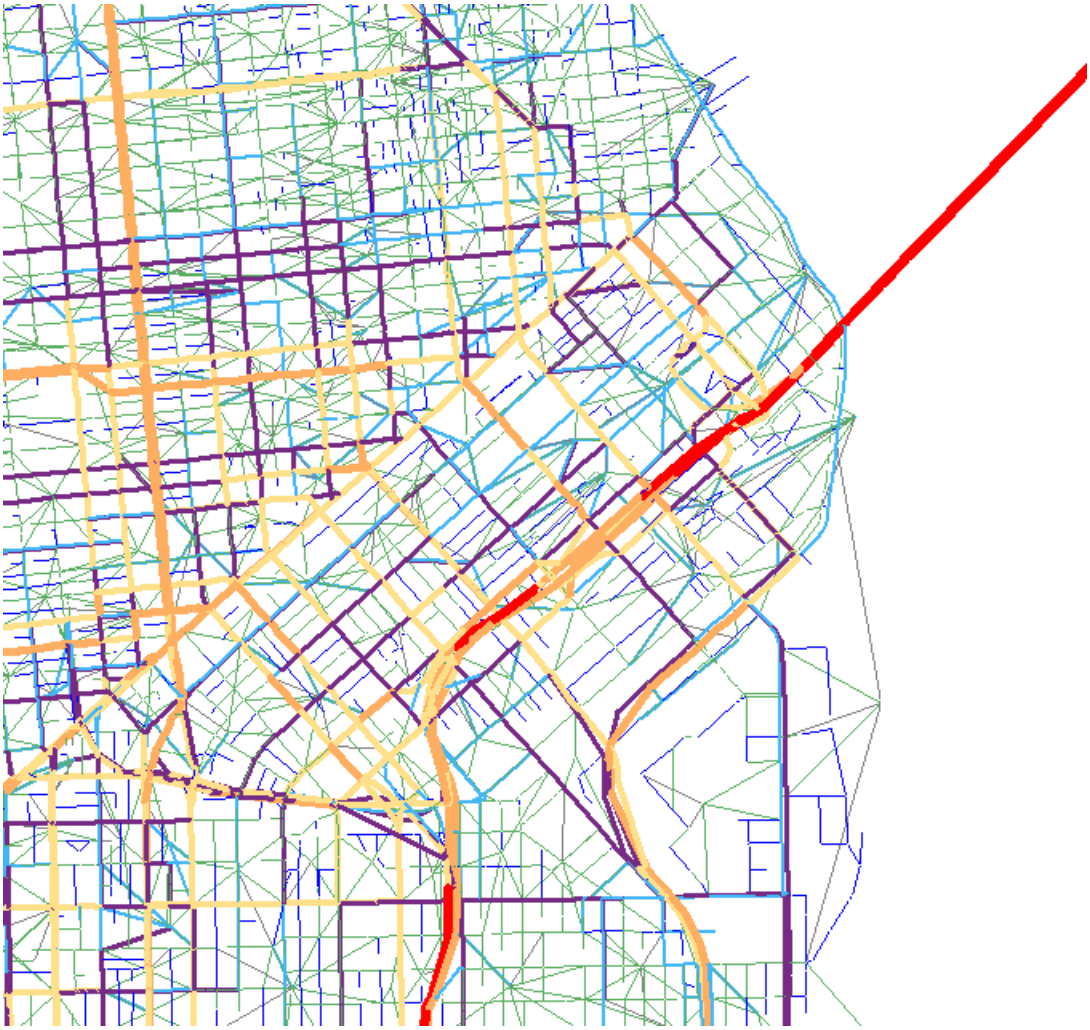


Figure 29: AM Peak Highway Assignment Volume Summary for Richmond-San Rafael Bridge Interchange in San Rafael

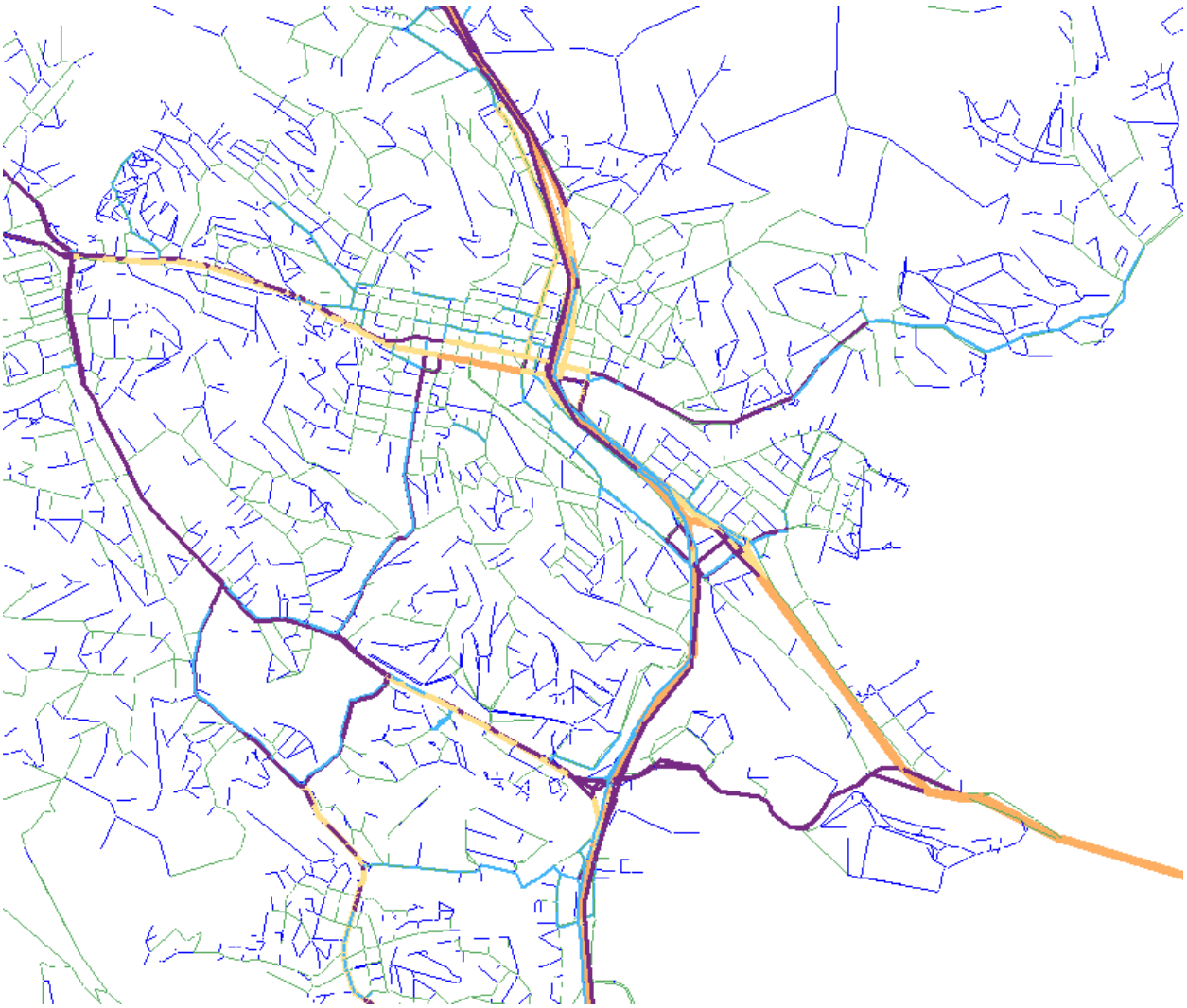
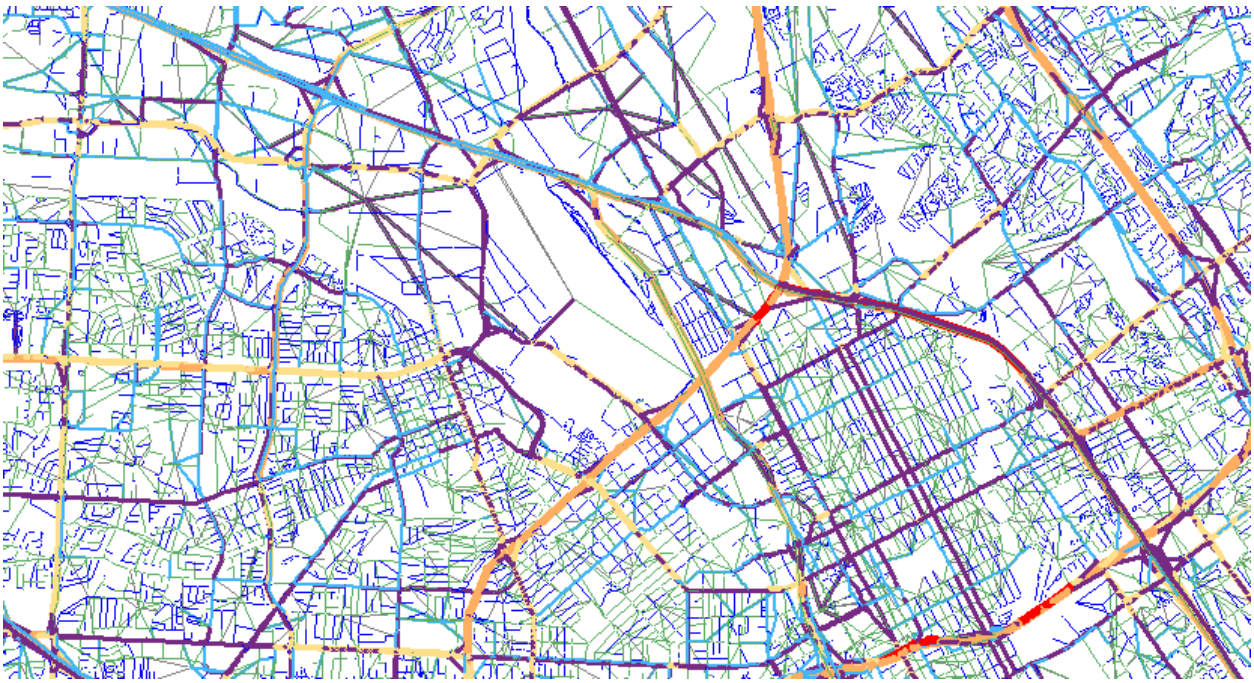


Figure 30: AM Peak Highway Assignment Volume Summary for SJC Airport Area (SJC is "blank" area in center of map)



A summary of the vehicle miles traveled for the highway assignments by county and time period was produced. This summary is shown in the table below. Overall, the results seem sensible, with consistent distributions across time periods and counties. Also, it is seen that the peak periods (AM and PM) have larger VMT than the others, as would be expected.

Table 35 : Highway Assignment Vehicle Miles Travelled Summary by County and Time Period

County	Vehicle Miles Traveled					
	EA	AM	MD	PM	EV	Total
Alameda	1,114,137	3,491,690	3,785,884	5,300,924	2,268,129	15,960,763
Contra Costa	648,287	2,318,055	2,628,482	3,099,828	1,484,619	10,179,272
Marin	909,997	802,507	766,273	1,840,047	530,168	4,848,992
Napa	34,783	282,258	343,084	421,171	180,766	1,262,062
San Francisco	470,908	1,592,282	2,158,682	1,959,840	931,855	7,113,567
San Mateo	930,749	2,661,818	3,376,741	3,379,191	1,347,599	11,696,097
Santa Clara	1,661,248	4,286,558	5,441,860	5,777,067	2,426,247	19,592,981
Solano	372,290	797,339	951,399	1,182,007	505,309	3,808,344
Sonoma	2,943,800	1,582,334	1,362,983	4,534,887	949,634	11,373,639
Total	9,086,199	17,814,841	20,815,389	27,494,961	10,624,326	85,835,716

11 Transit Assignment

Transit assignment is run using Cube's PUBLIC TRANSPORT program. For each of the five time periods, three transit assignments are performed: SET1 (Local only), SET2 (Local + Premium) and SET3 (Local + Premium with high transfer penalty).

The following table gives a summary of the transit assignment results, summing the number of passengers, the passenger miles, and the passenger hours for each assignment. The results are somewhat lumpy since they represent trips for only 33 percent of the households. Overall, the results look reasonable, with the split across time periods concentrated in the peak and, to a lesser extent, midday periods, when the demand for transit is higher and more transit lines are running. Also, the passenger split across SET1, SET2 and SET3 assignments shows more passengers in the SET1 assignment (which is dictated to some degree by the mode choice model) but a greater aggregate passenger distance in SET2 assignment. This indicates riders of premium transit use it for longer trips, which is also to be expected. Lastly, the aggregate premium passenger hours per trip (from SET2 and SET3) are higher than local (SET1), which also makes sense since it is expected that premium trips are longer than local trips.

Table 36 : Transit Assignment Passenger Summary by Time Period

Period	Passengers						Passenger Distance						Passenger Hours					
	SET1	%	SET2	%	SET3	%	SET1	%	SET2	%	SET3	%	SET1	%	SET2	%	SET3	%
EA	16,180	1%	13,737	1%	185	1%	40,795	1%	124,677	2%	2,669	1%	2,716	1%	5,087	2%	5,484	3%
AM	518,805	21%	333,686	30%	6,376	35%	1,227,789	25%	2,069,745	31%	62,326	30%	81,735	25%	89,906	31%	62,413	29%
MD	967,741	39%	308,472	28%	4,606	25%	1,764,124	35%	1,728,029	26%	56,809	27%	117,402	35%	75,443	26%	50,526	24%
PM	680,839	27%	297,229	27%	4,100	22%	1,319,305	27%	1,647,092	24%	47,271	22%	87,796	27%	70,562	24%	67,241	32%
EV	296,254	12%	146,600	13%	3,200	17%	621,050	12%	1,154,925	17%	41,025	20%	41,330	12%	49,937	17%	26,489	12%
Total	2,479,819	100%	1,099,724	100%	18,467	100%	4,973,063	100%	6,724,468	100%	210,100	100%	330,980	100%	290,936	100%	212,155	100%

The next five tables provide a summary of the transit assignment results by mode for each time period. The mode is identified as the transit line name provided in the transit line file. These tables include extra information on the number of stops, the distance, time, and average headways of the lines, and the average speed (which is calculated from the aggregate distance and time). For ease of presentation each table is split into two parts. Table *a* holds the information on Stops, Distance, Time and Speed while Table *b* holds the data in Headway and Passenger stats.

We see that SET1 and SET2 are the most used skims – this is understandable as the script identifies duplicates paths in skim sets and zeroes them out resulting in SET3 to have only about 6% additional TAP coverage while SET1 and SET2 still holds the majority of non-duplicate paths. Also note that distances in SET2 is far higher than SET1 even though the number of passengers is roughly the same – this is because SET1 includes only Local services and those tend to offer shorter service routes than Premium which is included in SET2. Also, all modes have some loading, which indicates the demand models and the transit skimming and assignment procedures are working together well. Based on this analysis we conclude that the transit assignment seems to be working mechanically and provide intuitive results. A more thorough analysis should be performed using the on board surveys to ensure route boardings and transfers.

Table 37a: EA Transit Assignment Summary by Line Mode

Mode	Stops			Distance			Time			Speed (Distance/Time)		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	52	0	0	17.16	0.00	0.00	68.41	0.00	0.00	15.05	--	--
WHEELS	334	203	55	123.98	70.70	16.51	494.25	282.19	65.91	15.05	15.03	15.03
San Francisco MUNI	4,328	3,859	707	677.72	692.00	129.82	2,706.13	2,595.87	477.28	15.03	15.99	16.32
samTrans	1,257	1,200	265	429.62	421.36	120.81	1,717.52	1,683.52	483.27	15.01	15.02	15.00
Santa Clara VTA	2,947	2,816	858	870.79	1,079.99	308.24	3,479.77	4,191.87	1,163.46	15.01	15.46	15.90
AC Transit	4,749	3,926	372	1,026.36	831.14	67.40	4,092.23	3,313.24	268.92	15.05	15.05	15.04
Union City Transit	207	207	0	56.82	56.82	0.00	225.99	225.99	0.00	15.09	15.09	--
AirBART	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
The County Connection	493	521	0	138.26	191.43	0.00	550.22	762.80	0.00	15.08	15.06	--
TriDelta Transit	544	538	0	238.16	222.48	0.00	950.15	887.42	0.00	15.04	15.04	--
WestCAT	75	147	0	26.04	145.02	0.00	103.77	579.11	0.00	15.06	15.03	--
Vallejo Transit	236	210	4	99.18	137.95	16.48	394.78	550.38	65.85	15.07	15.04	15.02
Rio Vista Delta Breeze	18	0	0	28.40	0.00	0.00	113.65	0.00	0.00	14.99	--	--
Fairfield-Suisun Transit	23	0	0	67.40	0.00	0.00	269.60	0.00	0.00	15.00	--	--
Benicia Transit	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Napa VINE	33	37	0	150.96	185.02	0.00	602.55	738.45	0.00	15.03	15.03	--
Sonoma County Transit	436	120	201	204.29	50.11	81.97	817.72	200.63	328.42	14.99	14.99	14.98
Golden Gate Transit	276	304	143	215.27	222.19	100.91	862.69	890.21	404.13	14.97	14.98	14.98
Dumbarton Express	0	68	0	0.00	39.82	0.00	0.00	159.21	0.00	--	15.01	--
AC Transbay	0	708	316	0.00	407.29	123.81	0.00	1,623.21	492.40	--	15.05	15.09
Golden Gate Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Vallejo Baylink Ferry	0	4	0	0.00	60.56	0.00	0.00	241.78	0.00	--	15.03	--
BART	0	235	175	0.00	441.19	330.51	0.00	882.15	660.82	--	30.01	30.01
Caltrain	0	119	0	0.00	325.82	0.00	0.00	651.57	0.00	--	30.00	--
Amtrak Capitol Cor. & Reg. Svc	0	22	0	0.00	159.20	0.00	0.00	318.40	0.00	--	30.00	--
Total	16,008	15,244	3,096	4,370.41	5,740.09	1,296.46	17,449.43	20,778.00	4,410.46	240.52	331.90	167.35

Table 37b: EA Transit Assignment Summary by Line Mode

Mode	Headway (Average)			Passengers			Passenger Distance			Passenger Hours		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	60.00	0.00	0.00	36.36	0.00	0.00	38.60	0.00	0.00	2.58	0.00	0.00
WHEELS	56.67	33.33	6.67	78.80	36.37	3.03	109.74	281.95	7.79	7.30	18.76	0.52
San Francisco MUNI	26.64	23.23	3.07	7,423.90	3,793.89	27.27	14,099.79	7,694.38	124.93	938.91	428.83	7.73
samTrans	53.33	46.67	7.78	1,000.31	248.56	9.09	3,772.29	1,517.03	143.63	251.58	100.95	9.58
Santa Clara VTA	38.38	41.22	11.22	1,937.09	663.96	30.30	5,289.34	3,947.44	373.93	351.79	237.41	24.41
AC Transit	51.17	41.17	2.33	3,988.65	1,012.43	12.13	8,251.64	2,649.77	63.27	547.72	175.88	4.20
Union City Transit	30.00	30.00	0.00	124.34	15.15	0.00	270.47	95.46	0.00	18.02	6.33	0.00
AirBART	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
The County Connection	40.59	49.41	0.00	248.46	266.61	0.00	546.18	1,188.19	0.00	36.23	79.05	0.00
TriDelta Transit	40.71	36.43	0.00	230.38	203.04	0.00	676.58	1,768.22	0.00	45.01	117.70	0.00
WestCAT	9.47	27.37	0.00	12.12	200.04	0.00	10.76	1,692.13	0.00	0.71	112.50	0.00
Vallejo Transit	30.00	35.45	2.73	136.36	54.54	3.03	283.29	300.81	49.93	18.79	19.98	3.33
Rio Vista Delta Breeze	60.00	0.00	0.00	9.09	0.00	0.00	20.69	0.00	0.00	1.38	0.00	0.00
Fairfield-Suisun Transit	40.00	0.00	0.00	9.09	0.00	0.00	101.14	0.00	0.00	6.74	0.00	0.00
Benicia Transit	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Napa VINE	48.00	60.00	0.00	18.20	124.28	0.00	269.20	2,811.13	0.00	17.90	187.08	0.00
Sonoma County Transit	45.00	15.00	22.50	381.87	6.06	12.12	2,747.32	84.74	165.56	183.46	5.67	11.07
Golden Gate Transit	40.00	55.00	27.50	545.37	81.86	18.19	4,307.60	828.09	365.07	288.01	55.21	24.36
Dumbarton Express	0.00	60.00	0.00	0.00	33.35	0.00	0.00	262.23	0.00	0.00	17.47	0.00
AC Transbay	0.00	52.50	15.00	0.00	678.76	18.18	0.00	6,158.60	226.61	0.00	409.35	15.07
Golden Gate Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vallejo Baylink Ferry	0.00	15.00	0.00	0.00	3.03	0.00	0.00	91.75	0.00	0.00	6.10	0.00
BART	0.00	29.09	22.73	0.00	5,551.15	51.52	0.00	76,113.80	1,147.84	0.00	2,536.19	38.25
Caltrain	0.00	60.00	0.00	0.00	572.86	0.00	0.00	10,321.90	0.00	0.00	344.04	0.00
Amtrak Capitol Cor. & Reg. Svc	0.00	60.00	0.00	0.00	190.89	0.00	0.00	6,868.98	0.00	0.00	228.95	0.00
Total	669.96	770.86	121.51	16,180.39	13,736.83	184.86	40,794.63	124,676.60	2,668.56	2,716.13	5,087.45	138.52

Table 38a: AM Transit Assignment Summary by Line Mode

Mode	Stops			Distance			Time			Speed (Distance/Time)		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	61	61	0	23.62	23.62	0.00	94.14	94.14	0.00	15.05	15.05	--
Stanford Marguerite Shuttle	214	145	136	88.26	42.42	36.91	354.16	169.98	147.98	14.95	14.97	14.97
WHEELS	879	757	622	412.55	364.63	282.10	1,644.67	1,453.33	1,124.95	15.05	15.05	15.05
San Francisco MUNI	6,350	6,573	4,029	992.29	1,117.51	712.44	3,962.23	4,282.96	2,694.48	15.03	15.66	15.86
samTrans	4,429	4,120	1,791	1,379.83	1,266.16	533.02	5,514.52	5,060.52	2,130.45	15.01	15.01	15.01
Santa Clara VTA	6,171	6,296	3,628	1,794.33	2,213.10	1,208.44	7,172.55	8,661.46	4,648.37	15.01	15.33	15.60
AC Transit	7,515	7,257	3,914	1,635.28	1,580.84	831.44	6,520.53	6,302.64	3,314.52	15.05	15.05	15.05
Union City Transit	312	312	75	84.42	84.42	19.94	335.76	335.76	79.58	15.09	15.09	15.03
AirBART	2	0	0	3.21	0.00	0.00	12.96	0.00	0.00	14.86	--	--
The County Connection	1,357	1,467	784	387.59	523.74	311.41	1,542.49	2,085.69	1,240.50	15.08	15.07	15.06
TriDelta Transit	1,058	960	617	540.41	509.75	285.11	2,155.80	2,033.70	1,137.08	15.04	15.04	15.04
WestCAT	277	292	107	121.33	265.65	77.31	483.20	1,058.41	307.05	15.07	15.06	15.11
Vallejo Transit	510	562	342	181.31	279.95	218.48	721.96	1,115.90	871.02	15.07	15.05	15.05
Rio Vista Delta Breeze	36	36	0	56.80	56.80	0.00	227.30	227.30	0.00	14.99	14.99	--
Fairfield-Suisun Transit	131	132	39	220.50	288.03	144.69	881.42	1,151.76	578.61	15.01	15.00	15.00
American Canyon Transit	23	0	0	17.40	0.00	0.00	69.34	0.00	0.00	15.06	--	--
Vacaville City Coach	465	268	0	122.98	70.68	0.00	487.88	280.09	0.00	15.12	15.14	--
Benicia Transit	0	43	0	0.00	56.30	0.00	0.00	225.72	0.00	--	14.97	--
Napa VINE	455	411	240	509.34	444.64	319.03	2,032.57	1,773.91	1,273.45	15.04	15.04	15.03
St. Helena VINE	48	48	0	18.39	18.39	0.00	73.07	73.07	0.00	15.10	15.10	--
Sonoma County Transit	2,784	1,680	0	1,316.96	753.08	0.00	5,268.50	3,013.26	0.00	15.00	15.00	--
Santa Rosa CityBus	550	427	0	126.26	91.38	0.00	506.25	366.08	0.00	14.96	14.98	--
Petaluma Transit	258	0	82	75.46	0.00	18.96	302.17	0.00	75.62	14.98	--	15.04
Golden Gate Transit	972	1,048	500	567.76	621.93	354.55	2,269.90	2,485.97	1,416.45	15.01	15.01	15.02
Dumbarton Express	0	150	102	0.00	97.15	56.76	0.00	388.29	226.75	--	15.01	15.02
AC Transbay	0	977	733	0.00	609.02	458.61	0.00	2,427.91	1,828.95	--	15.05	15.05
Alameda/Oakland Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Alameda Harbor Bay Ferry	0	2	0	0.00	8.50	0.00	0.00	34.01	0.00	--	15.00	--
Golden Gate Ferry	0	4	2	0.00	24.16	12.08	0.00	96.64	48.32	--	15.00	15.00
Blue and Gold	0	4	0	0.00	12.54	0.00	0.00	50.16	0.00	--	15.00	--
Vallejo Baylink Ferry	0	6	6	0.00	90.84	90.84	0.00	362.49	362.49	--	15.04	15.04
BART	0	348	348	0.00	662.35	662.35	0.00	1,324.29	1,324.29	--	30.01	30.01
Caltrain	0	320	320	0.00	1,012.29	1,012.29	0.00	2,052.41	2,052.41	--	29.59	29.59
Amtrak Capitol Cor. & Reg. Svc	0	22	22	0.00	159.20	159.20	0.00	318.40	318.40	--	30.00	30.00
ACE	0	6	0	0.00	36.31	0.00	0.00	72.63	0.00	--	30.00	--
	34,857	34,734	18,439	10,676.28	13,385.38	7,805.96	42,633.37	49,378.88	27,201.72	345.62	526.35	376.63

Table 38b: AM Transit Assignment Summary by Line Mode

Mode	Headway (Average)			Passengers			Passenger Distance			Passenger Hours		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	10.50	10.50	0.00	1,106.00	12.13	0.00	1,334.26	6.15	0.00	88.89	0.39	0.00
Stanford Marguerite Shuttle	33.00	12.17	10.92	3,039.19	1,048.39	24.24	4,578.33	2,009.99	32.99	306.44	133.93	2.18
WHEELS	45.17	35.86	25.86	4,848.38	933.34	130.34	11,242.28	4,103.70	1,113.14	746.54	272.26	74.01
San Francisco MUNI	20.54	20.64	10.50	216,770.88	112,405.85	1,875.68	404,358.55	213,746.35	3,250.56	26,919.82	11,966.55	210.16
samTrans	47.48	37.41	8.93	31,381.02	12,020.75	100.04	80,874.88	45,110.30	813.14	5,387.01	3,005.61	54.16
Santa Clara VTA	34.26	33.65	14.79	77,674.14	20,571.42	551.56	214,235.59	96,623.93	4,959.37	14,254.29	5,812.74	312.03
AC Transit	40.31	38.45	17.38	116,887.97	35,997.26	503.10	235,134.82	97,237.12	2,648.13	15,622.21	6,443.68	175.78
Union City Transit	40.00	40.00	6.00	1,421.11	130.29	51.51	2,503.78	351.84	532.61	166.70	23.37	35.45
AirBART	5.00	0.00	0.00	6.06	0.00	0.00	19.45	0.00	0.00	1.31	0.00	0.00
The County Connection	38.02	44.40	20.17	7,526.92	6,644.96	124.20	13,700.99	25,641.47	874.40	908.37	1,708.90	58.31
TriDelta Transit	48.00	39.43	17.14	8,781.36	1,972.64	93.95	26,872.33	15,265.41	1,242.84	1,786.33	1,015.99	82.65
WestCAT	27.19	26.09	9.69	678.74	2,911.85	24.25	1,366.95	22,705.25	218.75	90.85	1,507.71	14.48
Vallejo Transit	38.57	40.48	21.90	3,490.78	1,893.80	69.69	7,739.55	17,095.27	887.71	512.53	1,136.42	59.01
Rio Vista Delta Breeze	30.00	30.00	0.00	612.12	30.32	0.00	2,259.04	118.06	0.00	150.68	7.88	0.00
Fairfield-Suisun Transit	46.15	46.15	20.77	1,354.53	460.57	15.15	6,812.27	5,234.81	335.49	453.44	348.99	22.35
American Canyon Transit	60.00	0.00	0.00	103.05	0.00	0.00	171.03	0.00	0.00	11.28	0.00	0.00
Vacaville City Coach	43.33	23.33	0.00	3,636.11	30.30	0.00	6,853.35	85.19	0.00	452.72	5.60	0.00
Benicia Transit	0.00	60.00	0.00	0.00	63.63	0.00	0.00	406.14	0.00	0.00	27.08	0.00
Napa VINE	60.00	50.53	34.74	2,878.78	924.22	69.73	11,738.40	17,018.47	1,208.93	780.45	1,132.13	80.41
St. Helena VINE	60.00	60.00	0.00	166.68	15.15	0.00	217.60	14.10	0.00	14.36	0.93	0.00
Sonoma County Transit	59.03	26.13	0.00	16,763.43	224.26	0.00	74,945.00	2,827.64	0.00	5,001.30	188.36	0.00
Santa Rosa CityBus	36.92	27.69	0.00	3,599.78	27.29	0.00	6,621.03	53.71	0.00	442.45	3.59	0.00
Petaluma Transit	53.33	0.00	10.00	1,309.03	0.00	3.03	1,884.60	0.00	11.73	126.13	0.00	0.78
Golden Gate Transit	39.80	40.60	19.30	14,768.87	4,030.13	166.71	112,325.31	38,994.54	2,184.43	7,511.32	2,599.02	145.33
Dumbarton Express	0.00	36.00	24.00	0.00	2,384.73	21.21	0.00	14,281.28	289.91	0.00	950.34	19.29
AC Transbay	0.00	33.95	24.47	0.00	12,614.14	1,327.23	0.00	98,084.66	17,416.16	0.00	6,518.67	1,156.51
Alameda/Oakland Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alameda Harbor Bay Ferry	0.00	30.00	0.00	0.00	3.03	0.00	0.00	25.75	0.00	0.00	1.72	0.00
Golden Gate Ferry	0.00	30.00	15.00	0.00	21.21	3.03	0.00	256.21	36.60	0.00	17.08	2.44
Blue and Gold	0.00	40.00	0.00	0.00	21.21	0.00	0.00	132.99	0.00	0.00	8.87	0.00
Vallejo Baylink Ferry	0.00	30.00	30.00	0.00	6.06	6.06	0.00	91.93	183.49	0.00	6.11	12.21
BART	0.00	26.11	26.11	0.00	100,727.96	869.75	0.00	1,114,036.07	14,066.13	0.00	37,122.22	468.75
Caltrain	0.00	60.00	60.00	0.00	14,941.06	336.25	0.00	218,825.43	9,576.89	0.00	7,294.42	319.19
Amtrak Capitol Cor. & Reg. Svc	0.00	60.00	60.00	0.00	560.55	9.09	0.00	17,795.91	442.56	0.00	593.19	14.75
ACE	0.00	60.00	0.00	0.00	57.57	0.00	0.00	1,565.12	0.00	0.00	52.17	0.00
	916.61	1,149.56	487.67	518,804.93	333,686.07	6,375.80	1,227,789.39	2,069,744.79	62,325.96	81,735.42	89,905.92	3,320.23

Table 39a: MD Transit Assignment Summary by Line Mode

Mode	Stops			Distance			Time			Speed (Distance/Time)		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	61	28	0	23.62	10.44	0.00	94.14	41.50	0.00	15.05	15.09	--
Stanford Marguerite Shuttle	156	115	29	70.95	42.30	17.12	284.88	169.78	68.52	14.94	14.95	14.99
WHEELS	627	577	433	221.04	209.09	150.35	881.28	833.90	599.83	15.05	15.04	15.04
San Francisco MUNI	4,350	4,621	2,382	648.48	763.72	439.05	2,591.38	2,898.76	1,656.00	15.01	15.81	15.91
samTrans	3,014	2,921	1,529	867.93	857.81	432.54	3,469.43	3,429.02	1,728.26	15.01	15.01	15.02
Santa Clara VTA	4,919	4,987	3,053	1,377.06	1,596.83	956.67	5,504.26	6,231.83	3,686.28	15.01	15.37	15.57
AC Transit	6,691	6,556	3,090	1,444.96	1,416.79	649.71	5,761.64	5,649.11	2,593.13	15.05	15.05	15.03
Union City Transit	312	312	146	84.42	84.42	37.38	335.76	335.76	148.76	15.09	15.09	15.08
AirBART	2	0	0	3.94	0.00	0.00	15.85	0.00	0.00	14.91	--	--
The County Connection	1,369	1,382	569	388.69	433.20	182.10	1,547.29	1,724.42	725.16	15.07	15.07	15.07
TriDelta Transit	970	932	561	497.22	481.35	277.56	1,983.54	1,919.91	1,106.98	15.04	15.04	15.04
WestCAT	266	320	170	119.29	206.90	150.49	475.40	824.82	599.83	15.06	15.05	15.05
Vallejo Transit	423	482	351	149.37	238.79	194.82	594.88	951.87	776.90	15.07	15.05	15.05
Rio Vista Delta Breeze	33	33	0	56.16	56.16	0.00	224.70	224.70	0.00	15.00	15.00	--
Fairfield-Suisun Transit	87	87	3	121.42	121.42	32.42	485.23	485.23	129.61	15.01	15.01	15.01
American Canyon Transit	10	0	0	6.76	0.00	0.00	27.03	0.00	0.00	15.01	--	--
Vacaville City Coach	339	200	0	82.12	46.12	0.00	325.60	182.89	0.00	15.13	15.13	--
Benicia Transit	0	9	0	0.00	22.05	0.00	0.00	88.15	0.00	--	15.01	--
Napa VINE	407	407	63	214.43	214.43	90.52	854.06	854.06	360.98	15.06	15.06	15.05
St. Helena VINE	38	38	0	16.10	16.10	0.00	63.92	63.92	0.00	15.11	15.11	--
Sonoma County Transit	2,042	748	0	833.57	314.99	0.00	3,335.08	1,260.88	0.00	15.00	14.99	--
Santa Rosa CityBus	550	92	0	126.26	15.69	0.00	506.25	62.89	0.00	14.96	14.97	--
Petaluma Transit	235	0	0	72.87	0.00	0.00	291.84	0.00	0.00	14.98	--	--
Golden Gate Transit	460	587	265	296.61	364.39	144.41	1,185.86	1,455.87	576.94	15.01	15.02	15.02
Dumbarton Express	0	209	169	0.00	134.68	95.66	0.00	537.92	381.87	--	15.02	15.03
AC Transbay	0	265	224	0.00	205.26	165.59	0.00	819.36	661.33	--	15.03	15.02
Alameda/Oakland Ferry	0	13	0	0.00	24.33	0.00	0.00	97.20	0.00	--	15.02	--
Golden Gate Ferry	0	6	0	0.00	30.44	0.00	0.00	121.77	0.00	--	15.00	--
Angel Island - Tiburon Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Blue and Gold	0	12	0	0.00	28.65	0.00	0.00	114.62	0.00	--	15.00	--
Vallejo Baylink Ferry	0	17	0	0.00	195.85	0.00	0.00	783.03	0.00	--	15.01	--
BART	0	207	207	0.00	389.47	389.47	0.00	778.80	778.80	--	30.01	30.01
Caltrain	0	79	79	0.00	186.24	186.24	0.00	372.44	372.44	--	30.00	30.00
Amtrak Capitol Cor. & Reg. Svc	0	29	29	0.00	237.60	237.60	0.00	475.19	475.19	--	30.00	30.00
Total	27,361	26,271	13,352	7,723.27	8,945.51	4,829.70	30,839.30	33,789.60	17,426.81	345.64	497.02	331.98

Table 39b: MD Transit Assignment Summary by Line Mode

Mode	Headway (Average)			Passengers			Passenger Distance			Passenger Hours		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	23.75	3.75	0.00	2,612.04	3.03	0.00	2,566.37	3.91	0.00	170.64	0.25	0.00
Stanford Marguerite Shuttle	30.67	18.00	6.67	8,587.62	890.83	3.03	12,719.45	2,008.22	8.66	850.56	134.26	0.58
WHEELS	45.88	38.82	26.47	9,908.78	978.76	90.92	18,844.85	5,369.88	695.42	1,249.01	356.29	46.25
San Francisco MUNI	17.53	18.62	7.96	377,892.84	110,921.90	709.05	527,334.15	232,176.58	2,216.95	35,135.70	12,538.71	130.11
samTrans	50.75	44.59	15.82	56,051.56	6,103.01	242.45	119,708.97	26,799.90	2,610.34	7,971.11	1,784.83	173.90
Santa Clara VTA	37.97	36.37	16.87	162,920.55	30,421.80	569.72	384,359.79	144,478.56	6,023.61	25,570.56	8,496.17	383.15
AC Transit	38.53	37.26	12.96	243,598.00	29,031.21	615.15	403,598.68	75,341.47	3,274.13	26,818.63	5,000.28	217.55
Union City Transit	54.00	54.00	24.00	1,772.66	112.11	6.06	2,248.42	599.85	60.69	148.89	39.94	4.04
AirBART	5.00	0.00	0.00	9.09	0.00	0.00	35.81	0.00	0.00	2.40	0.00	0.00
The County Connection	50.00	52.50	19.38	19,384.25	4,457.40	93.95	30,949.28	19,210.33	731.37	2,049.82	1,277.59	48.53
TriDelta Transit	57.00	53.00	24.00	12,411.73	1,748.45	118.21	36,880.20	15,853.93	2,163.81	2,450.72	1,054.87	143.78
WestCAT	33.00	35.00	22.00	1,327.20	2,133.24	27.29	2,278.50	10,944.43	283.00	151.59	726.69	18.79
Vallejo Transit	39.38	50.63	37.50	6,566.35	2,005.95	254.53	11,407.81	16,980.02	2,676.99	756.09	1,128.97	177.95
Rio Vista Delta Breeze	60.00	60.00	0.00	2,224.22	384.84	0.00	5,816.42	1,265.45	0.00	386.78	84.46	0.00
Fairfield-Suisun Transit	60.00	60.00	10.00	2,021.11	378.77	3.03	8,457.91	4,851.94	90.20	562.76	323.43	6.01
American Canyon Transit	60.00	0.00	0.00	12.12	0.00	0.00	18.06	0.00	0.00	1.20	0.00	0.00
Vacaville City Coach	30.00	18.00	0.00	8,326.99	18.20	0.00	15,526.52	48.41	0.00	1,025.80	3.20	0.00
Benicia Transit	0.00	60.00	0.00	0.00	118.17	0.00	0.00	906.81	0.00	0.00	60.43	0.00
Napa VINE	56.92	56.92	13.85	4,712.13	763.64	57.58	15,448.94	14,366.03	876.77	1,025.17	954.52	58.29
St. Helena VINE	60.00	60.00	0.00	330.34	18.18	0.00	533.44	51.44	0.00	35.12	3.38	0.00
Sonoma County Transit	60.00	16.10	0.00	30,908.62	21.22	0.00	120,793.45	216.28	0.00	8,062.02	14.45	0.00
Santa Rosa CityBus	36.92	4.62	0.00	7,905.76	3.04	0.00	13,079.55	10.47	0.00	873.30	0.70	0.00
Petaluma Transit	53.33	0.00	0.00	3,263.56	0.00	0.00	3,961.68	0.00	0.00	265.55	0.00	0.00
Golden Gate Transit	43.85	53.08	21.92	4,993.70	5,502.78	281.80	27,555.40	39,533.74	3,741.08	1,838.25	2,632.45	249.24
Dumbarton Express	0.00	60.00	42.86	0.00	4,560.38	69.73	0.00	22,923.76	709.03	0.00	1,525.09	47.12
AC Transbay	0.00	49.09	38.18	0.00	3,945.20	196.98	0.00	21,988.36	2,434.38	0.00	1,463.85	161.76
Alameda/Oakland Ferry	0.00	60.00	0.00	0.00	9.09	0.00	0.00	65.90	0.00	0.00	4.39	0.00
Golden Gate Ferry	0.00	45.00	0.00	0.00	193.92	0.00	0.00	2,289.84	0.00	0.00	152.65	0.00
Angel Island - Tiburon Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue and Gold	0.00	33.33	0.00	0.00	130.31	0.00	0.00	788.30	0.00	0.00	52.55	0.00
Vallejo Baylink Ferry	0.00	60.00	0.00	0.00	9.09	0.00	0.00	251.63	0.00	0.00	16.77	0.00
BART	0.00	15.00	15.00	0.00	94,153.48	933.38	0.00	902,619.96	18,916.11	0.00	30,076.33	630.36
Caltrain	0.00	60.00	60.00	0.00	7,878.19	281.89	0.00	115,259.54	6,802.05	0.00	3,841.44	226.72
Amtrak Capitol Cor. & Reg. Svc	0.00	60.00	60.00	0.00	1,575.63	51.53	0.00	50,824.36	2,494.69	0.00	1,694.07	83.16
Total	1,004.49	1,273.68	475.43	967,741.22	308,471.82	4,606.28	1,764,123.65	1,728,029.30	56,809.28	117,401.67	75,443.01	2,807.29

Table 40a: PM Transit Assignment Summary by Line Mode

Mode	Stops			Distance			Time			Speed (Distance/Time)		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	68	68	0	27.26	27.26	0.00	108.63	108.63	0.00	15.06	15.06	--
Stanford Marguerite Shuttle	236	180	97	110.95	62.21	40.00	444.78	249.24	160.26	14.97	14.98	14.98
WHEELS	886	750	337	419.39	372.92	197.91	1,672.90	1,487.70	789.32	15.04	15.04	15.04
San Francisco MUNI	5,887	6,128	3,132	927.24	1,031.05	544.31	3,704.55	3,941.06	2,085.84	15.02	15.70	15.66
samTrans	3,809	3,491	2,007	1,153.31	1,069.58	559.45	4,609.46	4,275.67	2,235.43	15.01	15.01	15.02
Santa Clara VTA	5,361	5,651	2,982	1,585.07	2,039.62	1,041.23	6,334.16	7,998.88	4,024.17	15.01	15.30	15.52
AC Transit	6,805	6,598	2,387	1,470.34	1,430.64	515.59	5,863.07	5,704.37	2,055.27	15.05	15.05	15.05
Union City Transit	312	312	75	84.42	84.42	19.94	335.76	335.76	79.58	15.09	15.09	15.03
AirBART	2	0	0	3.94	0.00	0.00	15.85	0.00	0.00	14.91	--	--
The County Connection	1,450	1,577	575	416.47	554.22	214.11	1,657.66	2,206.95	851.90	15.07	15.07	15.08
TriDelta Transit	1,049	931	791	549.63	476.52	370.25	2,192.43	1,900.39	1,475.93	15.04	15.04	15.05
WestCAT	246	313	113	112.12	296.44	109.03	446.79	1,181.51	434.06	15.06	15.05	15.07
Vallejo Transit	465	524	233	163.37	252.79	156.91	650.79	1,007.78	625.09	15.06	15.05	15.06
Rio Vista Delta Breeze	24	24	0	43.16	43.16	0.00	172.70	172.70	0.00	14.99	14.99	--
Fairfield-Suisun Transit	108	106	14	150.57	219.91	96.42	601.90	879.40	385.44	15.01	15.00	15.01
American Canyon Transit	10	0	0	6.76	0.00	0.00	27.03	0.00	0.00	15.01	--	--
Vacaville City Coach	393	364	152	101.33	92.72	34.53	401.94	367.75	136.91	15.13	15.13	15.13
Benicia Transit	0	21	0	0.00	33.51	0.00	0.00	134.05	0.00	--	15.00	--
Napa VINE	437	434	102	394.73	368.27	202.66	1,574.58	1,468.93	809.31	15.04	15.04	15.02
St. Helena VINE	48	48	0	18.39	18.39	0.00	73.07	73.07	0.00	15.10	15.10	--
Sonoma County Transit	2,487	0	0	1,133.36	0.00	0.00	4,534.67	0.00	0.00	15.00	--	--
Santa Rosa CityBus	550	0	0	126.26	0.00	0.00	506.25	0.00	0.00	14.96	--	--
Petaluma Transit	265	0	0	74.51	0.00	0.00	298.19	0.00	0.00	14.99	--	--
Golden Gate Transit	611	753	449	460.21	530.46	249.97	1,840.63	2,120.76	998.82	15.00	15.01	15.02
Dumbarton Express	0	132	83	0.00	82.84	42.05	0.00	330.83	167.95	--	15.02	15.02
AC Transbay	0	867	486	0.00	604.41	349.71	0.00	2,412.56	1,395.65	--	15.03	15.03
Alameda/Oakland Ferry	0	17	0	0.00	37.34	0.00	0.00	149.25	0.00	--	15.01	--
Alameda Harbor Bay Ferry	0	2	0	0.00	8.50	0.00	0.00	34.01	0.00	--	15.00	--
Golden Gate Ferry	0	8	0	0.00	36.72	0.00	0.00	146.90	0.00	--	15.00	--
Angel Island - Tiburon Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Blue and Gold	0	12	4	0.00	31.78	11.16	0.00	127.17	44.66	--	14.99	14.99
Vallejo Baylink Ferry	0	4	0	0.00	60.56	0.00	0.00	241.78	0.00	--	15.03	--
BART	0	281	281	0.00	529.35	529.35	0.00	1,058.40	1,058.40	--	30.01	30.01
Caltrain	0	300	300	0.00	963.65	963.65	0.00	1,955.19	1,955.19	--	29.57	29.57
Amtrak Capitol Cor. & Reg. Svc	0	29	29	0.00	237.60	237.60	0.00	475.19	475.19	--	30.00	30.00
ACE	0	6	6	0.00	36.31	36.31	0.00	72.63	72.63	--	30.00	30.00
Total	31,509	29,931	14,635	9,532.79	11,633.15	6,522.14	38,067.79	42,618.51	22,317.00	345.62	511.36	391.38

Table 40b: PM Transit Assignment Summary by Line Mode

Mode	Headway (Average)			Passengers			Passenger Distance			Passenger Hours		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	25.50	25.50	0.00	1,730.22	18.17	0.00	1,792.31	50.42	0.00	119.53	3.35	0.00
Stanford Marguerite Shuttle	32.48	17.71	11.90	4,905.97	1,811.96	24.26	6,812.60	3,257.96	40.21	455.02	217.34	2.68
WHEELS	46.47	37.47	11.80	6,166.54	930.34	57.59	14,488.72	6,043.79	385.96	960.82	401.16	25.70
San Francisco MUNI	21.63	22.83	8.53	313,796.75	112,435.09	739.31	481,924.69	230,701.33	2,624.81	32,096.30	12,429.16	153.70
samTrans	48.22	34.79	15.24	37,116.46	5,745.45	293.96	82,707.44	21,237.97	3,033.12	5,504.86	1,411.18	201.86
Santa Clara VTA	32.85	34.57	12.22	97,451.59	28,825.20	603.07	237,696.58	133,791.11	5,522.51	15,812.57	7,789.08	346.88
AC Transit	39.47	37.99	9.65	149,661.35	21,180.59	372.68	280,881.83	50,151.76	2,464.03	18,668.75	3,327.81	163.64
Union City Transit	40.00	40.00	6.00	2,239.25	121.20	3.03	3,105.68	386.97	31.33	205.90	25.70	2.09
AirBART	5.00	0.00	0.00	9.09	0.00	0.00	35.81	0.00	0.00	2.40	0.00	0.00
The County Connection	40.18	47.86	13.21	10,505.72	4,081.69	103.05	19,539.09	16,145.60	813.52	1,294.61	1,072.14	54.07
TriDelta Transit	52.65	40.29	27.06	10,211.62	1,193.95	112.11	28,714.30	9,688.45	1,905.37	1,908.34	644.34	126.66
WestCAT	24.38	29.06	9.22	690.86	1,699.92	24.24	1,163.86	8,350.43	191.55	77.34	554.69	12.70
Vallejo Transit	40.00	48.33	15.00	3,851.32	1,566.58	99.99	7,349.48	11,424.59	1,280.04	487.65	759.30	85.16
Rio Vista Delta Breeze	40.00	40.00	0.00	1,439.35	293.92	0.00	4,311.44	861.68	0.00	287.25	57.80	0.00
Fairfield-Suisun Transit	41.67	41.67	11.67	1,021.14	415.13	57.57	5,469.29	5,681.06	1,304.29	364.07	378.66	86.94
American Canyon Transit	60.00	0.00	0.00	18.18	0.00	0.00	28.48	0.00	0.00	1.90	0.00	0.00
Vacaville City Coach	38.57	30.00	8.57	4,851.34	27.31	3.04	10,164.65	78.59	2.94	671.69	5.20	0.20
Benicia Transit	0.00	60.00	0.00	0.00	75.76	0.00	0.00	469.19	0.00	0.00	31.28	0.00
Napa VINE	57.65	54.12	21.18	3,145.50	781.81	18.21	12,792.26	17,925.12	298.67	849.81	1,192.18	19.87
St. Helena VINE	60.00	60.00	0.00	181.83	12.12	0.00	167.77	11.28	0.00	11.01	0.75	0.00
Sonoma County Transit	59.46	0.00	0.00	20,733.40	0.00	0.00	89,063.42	0.00	0.00	5,943.06	0.00	0.00
Santa Rosa CityBus	36.92	0.00	0.00	4,590.70	0.00	0.00	7,942.53	0.00	0.00	529.88	0.00	0.00
Petaluma Transit	46.67	0.00	0.00	2,033.26	0.00	0.00	2,643.04	0.00	0.00	177.03	0.00	0.00
Golden Gate Transit	41.82	48.18	27.73	4,487.66	3,869.52	184.84	20,510.19	26,759.39	2,146.60	1,366.67	1,780.52	142.69
Dumbarton Express	0.00	37.50	15.00	0.00	2,293.85	18.18	0.00	14,599.60	203.80	0.00	971.02	13.56
AC Transbay	0.00	32.57	18.00	0.00	8,750.80	221.21	0.00	32,445.75	2,528.75	0.00	2,160.71	168.22
Alameda/Oakland Ferry	0.00	60.00	0.00	0.00	3.05	0.00	0.00	2.60	0.00	0.00	0.15	0.00
Alameda Harbor Bay Ferry	0.00	30.00	0.00	0.00	6.06	0.00	0.00	51.51	0.00	0.00	3.43	0.00
Golden Gate Ferry	0.00	52.50	0.00	0.00	221.19	0.00	0.00	2,408.36	0.00	0.00	160.56	0.00
Angel Island - Tiburon Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Blue and Gold	0.00	51.43	17.14	0.00	227.25	63.63	0.00	1,233.30	382.24	0.00	82.26	25.48
Vallejo Baylink Ferry	0.00	15.00	0.00	0.00	9.09	0.00	0.00	0.55	0.00	0.00	0.04	0.00
BART	0.00	20.71	20.71	0.00	85,606.00	681.87	0.00	840,002.01	12,781.08	0.00	27,990.47	425.85
Caltrain	0.00	60.00	60.00	0.00	13,977.46	399.91	0.00	182,846.03	8,644.34	0.00	6,095.58	288.80
Amtrak Capitol Cor. & Reg. Svc	0.00	60.00	60.00	0.00	1,012.05	9.10	0.00	29,711.06	413.42	0.00	990.32	13.78
ACE	0.00	60.00	60.00	0.00	36.36	9.09	0.00	774.83	272.49	0.00	25.83	9.08
Total	931.58	1,230.09	459.83	680,839.10	297,228.87	4,099.94	1,319,305.46	1,647,092.29	47,271.07	87,796.46	70,562.01	2,369.61

Table 41a: EV Transit Assignment Summary by Line Mode

Mode	Stops			Distance			Time			Speed (Distance/Time)		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	66	0	0	26.20	0.00	0.00	104.51	0.00	0.00	15.04	--	--
Stanford Marguerite Shuttle	256	112	30	103.59	55.05	15.27	414.96	219.84	61.32	14.98	15.02	14.94
WHEELS	661	642	434	306.67	278.42	196.29	1,222.35	1,109.39	782.36	15.05	15.06	15.05
San Francisco MUNI	6,269	6,201	2,977	959.95	1,022.45	547.48	3,833.12	3,919.29	2,075.01	15.03	15.65	15.83
samTrans	2,170	2,166	1,148	682.61	700.60	395.36	2,728.24	2,800.38	1,580.41	15.01	15.01	15.01
Santa Clara VTA	4,514	4,716	2,601	1,288.86	1,516.15	820.58	5,148.17	5,922.59	3,156.13	15.02	15.36	15.60
AC Transit	8,088	7,625	3,633	1,758.42	1,683.70	736.74	7,011.01	6,712.45	2,936.09	15.05	15.05	15.06
Union City Transit	312	170	75	84.42	46.65	19.94	335.76	185.77	79.58	15.09	15.07	15.03
AirBART	2	0	0	3.21	0.00	0.00	12.96	0.00	0.00	14.86	--	--
The County Connection	1,226	1,315	386	340.30	444.84	125.71	1,354.98	1,772.00	500.92	15.07	15.06	15.06
TriDelta Transit	652	652	459	307.74	307.74	220.60	1,227.44	1,227.44	879.98	15.04	15.04	15.04
WestCAT	158	350	218	69.33	265.67	148.74	276.34	1,059.78	594.19	15.05	15.04	15.02
Vallejo Transit	334	393	169	130.74	220.16	116.10	520.39	877.38	462.01	15.07	15.06	15.08
Fairfield-Suisun Transit	13	24	14	69.92	149.73	96.42	279.54	598.86	385.44	15.01	15.00	15.01
Napa VINE	170	13	13	195.93	94.33	94.33	781.76	377.09	377.09	15.04	15.01	15.01
Sonoma County Transit	1,178	219	0	489.71	100.59	0.00	1,960.29	402.85	0.00	14.99	14.98	--
Santa Rosa CityBus	510	0	0	116.14	0.00	0.00	465.36	0.00	0.00	14.97	--	--
Golden Gate Transit	408	513	112	260.70	304.85	80.15	1,042.59	1,218.89	320.91	15.00	15.01	14.99
Dumbarton Express	0	113	113	0.00	64.44	64.44	0.00	257.27	257.27	--	15.03	15.03
AC Transbay	0	1,222	791	0.00	668.25	389.13	0.00	2,664.63	1,550.03	--	15.05	15.06
Alameda/Oakland Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Alameda Harbor Bay Ferry	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	--	--	--
Golden Gate Ferry	0	6	0	0.00	30.44	0.00	0.00	121.77	0.00	--	15.00	--
Blue and Gold	0	7	2	0.00	17.38	6.27	0.00	69.54	25.08	--	15.00	15.00
Vallejo Baylink Ferry	0	9	4	0.00	105.88	60.56	0.00	423.08	241.78	--	15.02	15.03
BART	0	217	213	0.00	427.11	414.54	0.00	853.97	828.85	--	30.01	30.01
Caltrain	0	246	246	0.00	753.82	753.82	0.00	1,535.54	1,535.54	--	29.45	29.45
Amtrak Capitol Cor. & Reg. Svc	0	29	29	0.00	237.60	237.60	0.00	475.19	475.19	--	30.00	30.00
Total	26,987	26,960	13,667	7,194.44	9,495.85	5,540.07	28,719.77	34,804.99	19,105.18	270.38	390.97	361.31

Table 41b: EV Transit Assignment Summary by Line Mode

Mode	Headway (Average)			Passengers			Passenger Distance			Passenger Hours		
	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3	SET1	SET2	SET3
Emery Go-Round	45.00	0.00	0.00	445.41	0.00	0.00	551.99	0.00	0.00	36.79	0.00	0.00
Stanford Marguerite Shuttle	43.33	21.43	2.86	2,481.75	1,045.39	6.07	3,534.05	2,173.03	19.01	236.24	145.02	1.27
WHEELS	50.48	44.76	29.05	2,375.78	1,090.96	48.51	6,075.16	7,559.30	325.20	402.92	501.34	21.56
San Francisco MUNI	25.57	23.90	10.23	136,872.45	41,521.50	666.60	213,769.10	99,226.35	1,956.04	14,232.41	5,330.31	120.74
samTrans	55.43	52.83	22.83	12,202.91	2,330.39	106.07	30,970.08	10,484.67	1,028.49	2,064.66	698.47	68.53
Santa Clara VTA	44.78	47.43	20.70	37,219.53	17,402.37	318.27	103,640.95	98,826.16	2,597.00	6,892.71	5,878.90	165.94
AC Transit	42.98	39.85	12.45	77,904.93	12,027.11	409.12	155,212.00	36,968.77	3,352.03	10,315.63	2,456.19	222.28
Union City Transit	48.00	24.00	6.00	421.25	24.24	3.03	496.78	45.60	31.33	32.87	3.02	2.09
AirBART	6.00	0.00	0.00	3.03	0.00	0.00	9.73	0.00	0.00	0.65	0.00	0.00
The County Connection	47.73	55.23	15.00	5,048.47	3,751.36	84.84	10,209.04	17,372.67	576.34	676.54	1,155.92	38.41
TriDelta Transit	56.25	56.25	33.75	3,233.28	1,430.22	42.43	9,665.27	16,346.09	637.61	642.44	1,087.93	42.38
WestCAT	16.67	31.85	18.89	242.41	1,103.10	39.40	340.00	6,422.14	370.09	22.63	426.80	24.55
Vallejo Transit	30.00	43.85	18.46	1,793.79	2,233.10	75.75	3,620.80	27,629.87	1,058.54	239.98	1,838.61	70.39
Fairfield-Suisun Transit	30.00	54.00	30.00	981.78	909.00	18.18	8,914.91	17,945.56	348.79	594.75	1,196.44	23.25
Napa VINE	60.00	17.14	17.14	775.70	54.56	6.06	2,391.32	855.27	96.72	158.71	56.97	6.44
Sonoma County Transit	60.00	11.25	0.00	9,439.16	9.10	0.00	55,517.26	129.41	0.00	3,704.78	8.64	0.00
Santa Rosa CityBus	35.00	0.00	0.00	3,060.46	0.00	0.00	5,290.01	0.00	0.00	352.95	0.00	0.00
Golden Gate Transit	46.36	57.27	10.91	1,751.52	2,133.24	15.16	10,841.64	20,535.32	220.36	722.44	1,368.77	14.69
Dumbarton Express	0.00	50.00	50.00	0.00	957.48	21.21	0.00	7,951.74	309.71	0.00	528.66	20.60
AC Transbay	0.00	45.56	22.22	0.00	4,493.92	354.61	0.00	28,334.15	4,255.21	0.00	1,881.43	281.56
Alameda/Oakland Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alameda Harbor Bay Ferry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Golden Gate Ferry	0.00	45.00	0.00	0.00	148.47	0.00	0.00	1,740.80	0.00	0.00	116.05	0.00
Blue and Gold	0.00	45.00	15.00	0.00	72.72	6.06	0.00	385.20	38.00	0.00	25.69	2.53
Vallejo Baylink Ferry	0.00	40.00	20.00	0.00	103.02	18.18	0.00	3,093.57	550.49	0.00	205.55	36.57
BART	0.00	32.50	27.50	0.00	41,608.56	651.51	0.00	530,015.35	12,572.37	0.00	17,662.49	418.97
Caltrain	0.00	60.00	60.00	0.00	10,605.18	269.81	0.00	171,783.45	8,980.52	0.00	5,727.46	299.31
Amtrak Capitol Cor. & Reg. Svc	0.00	60.00	60.00	0.00	1,545.34	39.40	0.00	49,100.49	1,700.88	0.00	1,636.61	56.70
Total	743.57	959.09	502.99	296,253.61	146,600.33	3,200.27	621,050.09	1,154,924.96	41,024.73	41,330.10	49,937.27	1,938.76

12 Model Runtimes

As described in the *Strategic Supply Design* technical paper, *Travel Model Two* includes a much more detailed zone system and comprehensive set of networks than *Travel Model One*. Because of this, the feasibility of the model run time has been an open question, and so a quantification of the actual runtime of the model is essential to judging its usefulness in practice. The following table presents a summary of the individual model component runtimes for a full model run with two feedback iterations, the first running a 20% population sample through CT-RAMP and the second running a 33% sample. This was run on a single computer (a separate computer was used for the matrix and household servers used in the CT-RAMP model) with 12 hyper-threaded cores (24 CPUs) and 144 GB of RAM. The run times for a distributed run with four computers will likely be 3 to 4 times faster. For this test, highway assignment uses only 3 iterations.

Table 42 : Model Runtime Summary for Two-Feedback Iteration Model Run

Model Stage	Runtime	
Premodel	34 Minutes 34 Seconds	
NonMotorized Skims	1 Hour 2 Minutes 14 Seconds	
MAZ-MAZ Motorized Skims	28 Minutes 0 Seconds	
Airport Trips	4 Minutes 1 Seconds	
	Iteration 1 (20% Sample)	**Iteration 2 (33% Sample)**
HwySkims	3 Hours 26 Minutes 36 Seconds	3 Hours 44 Minutes 18 Seconds
Transit Skims	1 Hour 7 Minutes 9 Seconds	1 Hour 6 Minutes 45 Seconds
CTRAMP	12 Hours 38 Minutes 12 Seconds	20 Hours 24 Minutes 48 Seconds
IX Trips	2 Minutes 55 Seconds	3 Minutes 34 Seconds
Truck Trips	6 Minutes 24 Seconds	8 Minutes 12 Seconds
MAZ-MAZ Assignment	1 Hour 12 Minutes 0 Seconds	1 Hour 6 Minutes 37 Seconds
TAZ-TAZ Assignment [3 iterations]	3 Hours 29 Minutes 54 Seconds	2 Hours 56 Minutes 1 Seconds
Transit Assignment	1 Hour 10 Minutes 42 Seconds	
Total Runtime	2 Days 6 Hours 53 Minutes 1 Seconds	

It is shown that the overall runtime for the model is about 2.3 days, which is feasible, and that none of the individual components seems to take an excessive amount of time. If scaled up to a full 100% sample, a full CT-RAMP run (which took 8 and 15 hours respectively) would be expected to take a bit over 3 days. However, since the CT-RAMP model can be distributed quite efficiently, a larger cluster with more computing cores should reduce this significantly.

It is important to note that the highway assignments were only run for 3 iterations, with each iteration taking just under 1 hour. This too would benefit from the use of a larger number of CPUs, as well as (possibly) a reconfiguration of the way that the assignment is distributed so that cores are not left idle when some time periods' assignments converge more quickly than others (e.g. EV vs. AM).

It is also noted that these runtimes are consistent between different runs. This consistency is seen in comparing the two feedback iterations' runtimes for non-CT-RAMP components, but was also seen for

other components such as non-motorized skims when multiple runs were made during the debugging stages of this verification process.

13 Conclusions

Travel Model Two is a substantial upgrade to *Travel Model One*. On the supply side, it has a significantly more detailed highway, non-motorized and transit network and an enhanced zone system. The study region is now represented using about 4,700 TAZs and 39,000 MAZs – such a fine representation of space ensures that accessibilities are calculated more accurately than before. The network is built using an "all streets" network that has information up to the level of local streets and even pedestrian and bike trails. On the demand side, a significant amount of ABM improvements has been incorporated into this model – some of which have been tested in other regions and other features that are new and innovative. These changes have resulted in the complete revamping of the MTC travel model.

In this technical memorandum we have looked at individual model components of the new model and ensured that it is working as expected and producing intuitive results. Although here we have shown that the model is performing as designed, the various model components would need to be calibrated and validated to ensure that *Travel Model Two* replicates the base year conditions in the Bay Area.